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FORESTRY AS A FARM ENTERPRISE IN WASHINGTON PARISH, LOUISIANA

By

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The Occasional Papers of the Southern Forest Experiment Station present information on current Southern forestry problems under investigation at the Station. In some cases these contributions were first presented as addresses to a limited group of people, and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

FORESTRY AS A FARM ENTERPRISE IN WASHINGTON PARISH, LOUISIANA [1]

By W. E. Bond, Senior Forest Economist
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Practically every farm in Washington Parish, La., has its woodland. Annual crops of fence posts and fuel wood, as well as occasional crops of sawlogs and pulpwood, are harvested from this woodland, just as cotton is harvested from the cotton patch. The woodland is a part of the farm acreage; as such it constitutes a part of the farm investment and yields a part of the farm income. It is used for grazing livestock. Mules, wagons, axes, and similar capital used in other farm enterprises are used part time in harvesting woodland crops, and some of the family labor is so expended.

Farm forestry is, therefore, one of several enterprises on the usual farm. At present it is a minor one in spite of the fact that woodland generally makes up about 40 percent of the usual farm area of 40 to 60 acres. Cotton growing, for which about 25 percent of the total area is used, is the only commercial enterprise of importance. Washington, one of the so-called Florida Parishes (fig. 1), is characterized by small owner-operated farms, tilled with simple tools. Cash income, chiefly from cotton, is small, but farm and family requirements for food and feeds are largely supplied from other farm enterprises. The farm forest now furnishes wood and posts for household and farm needs, but little cash income. Before the farmer will voluntarily develop it into a major farm enterprise he must be convinced that good woodland management has a reasonable chance of yielding a net income above any additional expense.

1/ The study reported in this Occasional Paper was made as a part of the Bureau of Agricultural Economics - State Agricultural Experiment Station farm management project under a cooperative agreement signed by the following agencies: Bureau of Agricultural Economics, Soil Conservation Service, Forest Service, and Louisiana Agricultural Experiment Station. Pursuant to the terms of the agreement the Soil Conservation Service made timber inventories and growth studies, besides obtaining records of timber used and sold on sample farms; the Forest Service supervised the field work, analyzed the field data, and prepared the report on the farm forestry enterprise. This report will be published by Louisiana State University as a part of a larger report covering all farm enterprises. In order to make the farm forestry report more widely available it is being published, with the consent of all cooperating agencies, as an Occasional Paper.

it might entail. He will also be interested in knowing the probable demands upon his time, both as to the total required and the seasons when work can be done. The purpose of the study reported herein was to appraise the present and potential contribution of farm woodlands to the farm economy. If management of farm woodlands can be shown to produce cash returns, it is clearly a possible adjustment of the farm organization and practices.

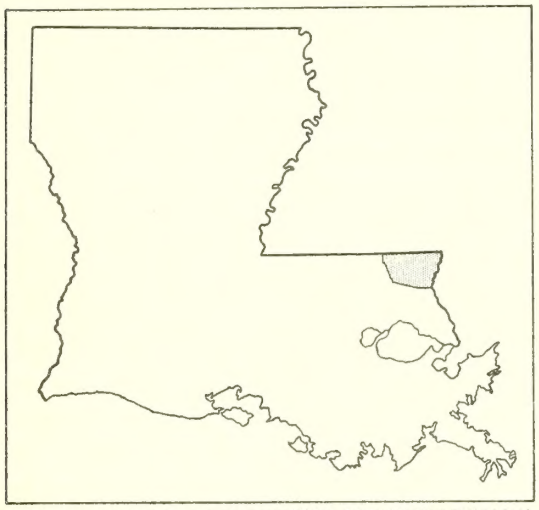


FIGURE 1.—LOCATION OF WASHINGTON PARISH IN LOUISIANA.

Improvement and management of farm woodlands fits in well with the usual organization of the farm. The farmer already has an area of woodland which is capable of contributing more substantially to the farm economy than at present. In most cases the woodland contains enough timber to produce the annual household and farm requirements for fuel wood and fence posts, along with a fair stocking of young growth and a sufficient number of seed trees to restock the area naturally, so that costs of planting artificially are not involved. With a long growing season, favorable distribution of rainfall, and an excellent site, trees probably grow as rapidly in Washington Parish as in almost any section of the South. The farmer does not need to fertilize or cultivate the individual trees; instead, while he works his cotton and handles the other crops on his farm, trees grow naturally. In nearly all woodlands, however, the growing stock needs to be built up in quantity and quality. These aims can be accomplished by frequent light improvement cuttings made during the winter months when the farmer has much free time. In tending the woodland crop, the ax is accordingly the principal cultural tool. No complicated plan of cutting and management is necessary, but a few simple rules must be followed in improving farm woodlands.

Farm Woodlands in Washington Parish

Washington Parish is generally considered to be in the longleaf pine region, yet on only a very small number of the farm woodlands studied was longleaf pine the predominant species. The predominating type was loblolly pine and hardwoods, with scattered individuals of shortleaf and longleaf pine. This is largely accounted for by the fact that the farms are small and the woodlands are usually limited to the branch bottoms and slopes that are too wet or too steep for cultivation, but are natural sites for loblolly pine and hardwoods. Furthermore, longleaf pine does not naturally restock as prolifically as loblolly pine; therefore loblolly is quite generally replacing the longleaf, even on areas which originally bore practically pure stands of virgin longleaf timber. The hardwoods associated with the pine are red oak and post oak on the drier uplands and redgum (sweetgum) and blackgum (black tupelo), water and white oak, yellowpoplar, and some other less valuable species on the moister sites. In a few cases, the pine-hardwoods give way to bottomland hardwoods, composed mostly of "gum," magnolia, water oak, and more

rarely, cypress. Because of the predominance of loblolly pine-hardwoods, and also because of the limited nature of this study, the results given here are confined to this type.

The farm woodlands in Washington Parish are generally of small acreage. The AAA records show that 39 percent of the farms of the parish have less than 20 acres classed as "other lands," including woodlands, open pasture, and waste land. An additional 22 percent of the farms in the parish have from 20 to 39 acres in "other land." The average one-mule cotton farm has 22 acres of cropland and 20 acres of "other land," and the average two-mule cotton farm has 33 acres of cropland and 32 acres of "other land." Inventories of farm woodlands made during this study showed that on the one-mule farm 15 of the 20 acres of "other land" was in woods, and on the two-mule farm 25 of the 32 acres of "other land" was in woods.

As a rule, farm woodlands are overcut, overgrazed, and burned over frequently. In many cases, the heavy annual drain for fuel wood and the occasional sale of merchantable material during hard years have removed the best pines and hardwoods of merchantable size—the crop trees--and left only poor-quality trees of the larger sizes—the weeds—together with trees of small sizes. On a small farm, grazing is often heavy, and fire is sometimes used in an effort to eliminate underbrush and establish more and better grass. In spite of mistreatment, however, the usual farm woodland, although seriously deficient in trees of sawlog size, has succeeded in restocking itself with young growth, which, if properly managed, will supply current farm needs and yield a gradually increasing volume of salable material. A small percentage of farm woodlands have been well managed and now contain well-stocked stands that can yield a considerable immediate income. Table 1 gives the average stand for the usual farm woodland, including all except the best 10 percent, and table 2, the average stand for the best 10 percent of all stands. These tables show by diameter classes the number of good trees (potential saw-timber trees) and the number of poor trees (which should be utilized for pulpwood, fuel wood, or other low-quality products). Attention is called to the significant predominance of unprofitable hardwoods in the usual stand that has resulted from years of poor cutting practices. The stand representing the best 10 percent is a good example of what the usual woodland can be built up to if good forestry is practiced for several years.

Forest Products Used on Farms

The fuel commonly used in the household for cooking and heating is wood cut on the farm, obtained from other land without cost, or in a few cases purchased. The fact that farmers must have this fuel wood is the main reason that they keep some of their land in woods instead of clearing it for cropland. A canvass of the farms showed that about 9.6 cords of wood is consumed annually on the usual one-mule cotton farm and about 11 cords annually on the usual two-mule cotton farm. Of the fuel wood used on the one-mule cotton farms, about 85 percent is cut from their own woodlands, averaging 15 acres each. The 25-acre woodlands on the two-mule cotton farms provide practically all the fuel wood needed on such farms. If all fuel wood were purchased, it would take about 25 percent of the cash income from cropland on the one-mule farm and almost 20 percent on the two-mule farm, assuming an average price of $4.00 per cord.

Table 1.—Average number of trees per acre in the usual farm woodlands, loblolly pine-hardwood type

Diameter breast high (inches)	Good trees					Poor trees					Total		
	Pine	Oak	"Gum"	Other hdwds.	Total	Pine	Oak	"Gum"	Other hdwds.	Total	Pine	Hdwd.	Total
4	47.30	3.28	2.02	2.99	55.59	2.41	6.77	2.37	4.67	16.22	49.71	22.10	71.81
6	21.95	2.94	2.19	2.18	29.26	.32	9.99	6.33	8.08	24.72	22.27	31.71	53.98
8	8.79	1.48	1.56	1.24	13.07	.04	3.93	3.59	4.15	11.71	8.83	15.95	24.78
10	3.81	.79	1.31	.62	6.53	.02	1.87	1.35	1.77	5.01	3.83	7.71	11.54
12	2.57	.45	.93	.52	4.47	.02	1.17	1.07	1.15	3.41	2.59	5.29	7.88
14	1.24	.55	.73	.35	2.87	.01	.60	.67	.67	1.95	1.25	3.57	4.82
16	.93	.37	.49	.16	1.95	..	.64	.42	.63	1.69	.93	2.71	3.64
18	.39	.13	.13	.09	.74	.01	.17	.06	.09	.33	.40	.67	1.07
20	.16	.03	.06	.05	.30	..	.02	.02	.03	.07	.16	.21	.37
22	.03	.03	.02	.06	.14	..	.01	.07	.03	.11	.03	.22	.25
24	.01	.04	.02	.03	.10	..	.04	.02	..	.06	.01	.15	.16
Total	87.18	10.09	9.46	8.29	115.02	2.83	25.21	15.97	21.27	65.28	90.01	90.29	180.30

Table 2.—Average number of trees per acre in the best 10 percent of farm woodlands, loblolly pine-hardwood type

Diameter breast high (inches)	Good trees					Poor trees					Total		
	Pine	Oak	"Gum"	Other hdwds.	Total	Pine	Oak	"Gum"	Other hdwds.	Total	Pine	Hdwd.	Total
4	56.10	17.34	2.60	3.34	79.38	1.03	6.34	2.86	1.93	12.16	57.13	34.41	91.54
6	39.79	7.81	.86	.83	49.29	.64	5.81	3.17	1.79	11.41	40.43	20.27	60.70
8	24.29	2.50	1.07	.45	28.31	.24	1.36	2.26	.74	4.60	24.53	8.38	32.91
10	10.41	.16	.28	.59	11.44	.19	.64	.79	.45	2.07	10.60	2.91	13.51
12	6.86	.59	.48	.31	8.24	.19	.84	.57	.16	1.76	7.05	2.95	10.00
14	6.47	.48	.34	..	7.29	.16	.34	.50	.16	1.16	6.63	1.82	8.45
16	2.24	.38	.09	.09	2.80	..	.76	.66	.16	1.58	2.24	2.14	4.38
18	3.48	.64	.09	..	4.21	..	..	..	.16	.16	3.48	.89	4.37
20	1.07	.16	.09	..	1.32	..	..	.09	..	.09	1.07	.34	1.41
22	.36	..	..	..	.36	..	..	..	..	..	.36	..	.36
24	.24	..	..	..	.24	..	...	..	..	..	.24	..	.24
Total	151.31	30.06	5.90	5.61	192.88	2.45	16.09	10.90	5.55	34.99	153.76	74.11	227.87

In most cases, there is ample fuel wood on the farm woodland if all available noncommercial trees are utilized properly. This necessitates using blackjack oak, hickory, and other unmerchantable species, together with limby "wolf" trees and scrubby individuals of oaks, "gums," and other merchantable species. Lightwood (resinous pine), which formerly could be procured without cost on lands belonging to large companies, is now scarce. Pine fuel wood on the farm woodlands is also limited, since farmers have depleted their stands by cutting pine trees for stove wood because they split easily, and leaving uncut the hardwoods, which are more difficult to split. If farmers are willing to cut their fuel wood early enough to allow proper seasoning before use, there is no reason why the bulk of the fuel wood cannot come as a byproduct from hardwoods, especially those unsuitable for saw timber.

Another drain upon the farm woodland is the cutting of fence posts. The study showed that about 60 fence posts are used each year on a small farm. Approximately the same number of fence posts are used on farms of both one-mule and two-mule classes. Only about two-thirds of the fence posts used on the one-mule farm were cut from the farm woodland, while practically all used on the two-mule farm were home products. In general, farmers are not keeping their fences up well and the post situation is becoming more critical each year. Pine lightwood posts can no longer be obtained without cost, and good heartwood posts are scarce. The farmer is therefore often forced to use sap-pine or sap-hardwood for posts; these last only 1 or 2 years in the ground and then must be replaced. This replacement is a heavy drain on the farmer's time as well as a heavy drain on the woodland. Black locust, oak, mulberry, cherry, and sassafras heartwood posts are being purchased to some extent, but at an average price of about 8 cents the farmer cannot afford many of them. Some farmers are cutting posts as thinnings from thick stands of young pine saplings. These are peeled and taken to the treating plant in Bogalusa, where they are given a pressure creosote treatment, costing about 8 to 12 cents per post. Such posts usually do not need to be replaced during the life of the farmer.

Good saw timber is relatively scarce on the usual farm. The canvass of 66 farmers disclosed that during a 10-year period (1930-39) only 22 of them cut saw timber from their woodlands, had it sawed into lumber, and used it on the farm. A total of 81,100 board feet was cut, an average for the 66 farms visited of 1,229 board feet each in the 10-year period, or 123 board feet annually. Lumber was purchased for use on the 22 farms in addition to that sawed from home-grown logs. Of those farmers who did not cut saw timber from their woodlands, 14 reported using lumber. A total volume of 89,860 board feet of lumber was purchased and used, an average for the 66 farms of 1,361 board feet each during a 10-year period, or 136 board feet per farm annually. The volume of lumber used on the average farm during the 10-year period was, therefore, only 2,590 board feet, or 259 feet annually. Data on existing farm buildings indicates that they are inadequate and are not being maintained in good repair. Evidently, the farmers with low incomes cannot afford to spend much money for lumber. The average price paid for the lumber purchased during the last 10 years was $26.22 per thousand feet at the lumber yard.

Market Outlets and Prices

Out of the total of 66 farms visited, 31 farms reported sales of forest products in the 10-year period 1930-39. Table 3 lists the different items and shows that forest products to a total value of $2,735.09, or $41.44 per farm, were sold during the 10 years. The average annual sale value of forest products per farm was only $4.14. Very probably an advisory technical agency could have suggested sales methods that would have obtained better prices.

Table 3.--Total forest products sold in 10 years[1] from 66 farms in Washington Parish, La.[2]

Product	Total	Quantity and unit	Price per unit
	Dollars		Dollars
Ties (cut and delivered)	200.00	500 ties	0.40
Pulpwood (stumpage)	336.50	630 units[3]	.53
Pulpwood (cut, or cut and delivered)	430.55	241 units[3]	1.79
Saw timber (stumpage)			
a. Recorded	573.29	117.4 M bd.ft.[4]	4.88
b. Estimated	500.00	(Sold by lot)	(Unknown)
Sawlogs (delivered)	415.00	28.0 M bd.ft.[4]	14.82
Poles (delivered)	279.75	98 poles	2.85
Total	2,735.09		
Average, 31 farms reporting sales	88.23		
Average, 66 farms	41.44		

1/ 1930-39.
2/ Of 66 farms visited 31 reported sales.
3/ (4' x 5' x 8').
4/ Doyle rule.

In Washington Parish there are market outlets for practically all forest products. Early in 1940, pine saw-timber stumpage brought from $4 to $10 per thousand; white oak, yellowpoplar, and magnolia averaged about $6 per thousand; and red oak, "gum," and other less valuable species averaged about $4 per thousand. Logs delivered at the mill brought from $4 to $6 more than the stumpage price. For pulpwood, the farmer usually received from the contractor (who furnishes pulpwood to the pulp mill) 50 cents per unit (4' x 5' x 8') of stumpage or $1.50 per unit cut and stacked by a woods road. The price was $3.75 for a unit delivered at the pulp mill, or somewhat less delivered at the railroad. Poles and piling brought more than any other forest product, the price varying greatly according to size and length. Pine and hardwood cross ties sold for approximately 30 to 60 cents per tie delivered at the railroad. Peeled pine posts and heart hardwood posts brought about 5 to 10 cents each when delivered at the treating plant or at the shipping point. The market for fuel wood is rather limited, but a cord of pine or hardwood stove wood delivered in town brought about $5 to $6 per cord, and fireplace wood about $4 a cord. With the present market outlets, the farmer can find a ready sale for any high-quality material that he may produce. Several sawmills in the parish purchase stumpage and sawlogs. There is also a steady market for pulpwood. The poor-quality hardwoods may offer a problem, but ties can often be cut from them; moreover, it will be shown in a later section that after providing fence posts and fuel wood for home use on the usual farm, there will be no surplus of hardwoods.

Improvement and Management of Farm Woodland

A cotton field choked with weeds will not produce a large yield of cotton. In order to obtain a high yield, the farmer removes these weeds by cultivating; likewise, if the stand of cotton is too heavy, he chops out some of the plants, selecting the individuals that are vigorous and spaced well for good growth; and if part of the field is flooded so that the plants are killed, he reseeds it. He spends his time and money in these different operations because he knows they will result in a larger yield of cotton and a greater net income.

The average farmer in Washington Parish has not shown as much progressiveness in adopting practices to increase yield and net income from his farm woodland as he has shown in growing cotton. Most of his income has come from cotton and only a trifle from woodland products, and in all fairness he should not be criticized severely because of this lack of progress and interest in woodland management. Originally, most of these farms were cleared from cut-over timberlands, and the owners had to get rid of trees to make way for crops. Usually all land was cleared except a small woodland that was unfit for cultivation or was regarded as an essential source of fuel wood, fence posts, and other products used on the farm. Having only a small cash income from his cropland during good years, it was natural that during a year of poor crops or poor prices the farmer should liquidate any merchantable timber available on his woodlands in order to obtain money for the bare necessities of life. For the farmer with a small acreage of cut-over woodland, there was little incentive to protect and manage it for products higher in value than posts and fuel wood, and the growing of commercial crops of timber for harvesting in the uncertain future had little appeal to him. This is not surprising, since

the average farmer until very recently had hardly heard of woodland management, and had no concrete conception of the financial possibilities of such management.

It should not be expected, therefore, that this traditional attitude toward farm woodlands will suddenly give way to an enthusiastic desire to practice farm forestry. On the contrary, before farmers generally adopt good forest practices, considerable time must elapse and much untiring activity in educational work will be required of those agencies dealing with farm forestry. First of all, before any real progress can be made, the following bad practices must be stopped:

1. Indiscriminate, wasteful use of saw-timber trees or potential saw-timber trees for fuel wood and fence posts.
2. Destruction of pine and hardwood seedlings—the future crop of saw-timber trees—by burning over the woodland to improve grazing.
3. Overgrazing the woodland, which keeps down the natural reproduction of pine and hardwoods.
4. Serious overcutting of the woodland resulting from the practice of periodically selling all merchantable logs and pulpwood for a lump sum.

Before setting up probable yields and income that can be expected from managing the usual farm woodlands in Washington Parish, it is pertinent to ask: What practices are necessary to improve the farm woodland and to place it under good management? Good management of the farm woodland is not very different from good farming. A complicated management plan is not needed; on the contrary, only the following relatively simple practices are required:

1. Control forest fires. Without adequate fire protection, management in loblolly pine and hardwoods is useless, since uncontrolled fires prevent natural regeneration and destroy or at least seriously damage premerchantable or even saw-timber growing stock. The farmer can generally prevent fires in these woodlands without special effort, but it may be necessary in some cases to plow furrows and burn a strip between his woodland and adjoining woodlands where fires are not controlled.

2. Make improvement cuttings. The removal of defective and poor-quality trees will improve both the density and the value of the growing stock, affording more light and space for the better trees and greatly accelerating their growth. Fuel wood for the household and perhaps some current income from sale of ties or pulpwood can be obtained by utilizing blackjack oak, hickory, and other species of little commercial value, defective and scrubby individuals (not containing sawlogs) of pine, oak, and other commercial species, and tops of pine and hardwood saw-timber trees. Not only will this improve the condition of the stand, but it will save the pine and better-formed hardwoods until they have reached good saw-timber size.

3. Build up the saw-timber growing stock by limiting the cut during each 5-year period to 20 percent of the saw-timber volume. Growth studies in Washington Parish indicate that such cutting will result in automatic sustained-yield management. During the first period, when open stands are growing rapidly, cuts of 20 percent of the saw-timber volume (measured in board feet) will remove considerably less than the growth and understocked

stands will be built up, but during later periods after stands become more fully stocked and growth has decelerated, 20 percent of the saw-timber growing stock will approximately equal the growth. Light cuts at 5-year intervals or at shorter periods if practicable provide a means of salvaging trees that are infested with insects or dying from other natural causes. They also provide for liquidating overmature trees and for thinning overcrowded stands. Although improvement cuttings throughout the woodland for fuel wood and other home needs may be made each year, and although annual incomes from sale of woodland products are very desirable, annual cuts of saw timber are not feasible in the depleted stands on the small woodland areas. Therefore cuts once each 5 years are recommended in order that the cut per acre may be heavy enough to justify a commercial operation. The cuts need not be made exactly at 5-year intervals, however; market conditions and the financial needs of the owner should be given consideration in deciding when to cut. Cuts at intervals of less than 5 years should be made where and when they become economically practicable.

4. Select and mark merchantable trees to be cut, so as to build up the quality of the growing stock. Proper selection is the heart and foundation of good management practices. Real improvement of cutting methods demands that every tree be marked before cutting is permitted. The object in marking the 5-year cut should be to leave the stands in the best condition possible for future growth by reserving immature trees, and at the same time to make the current operation yield the largest possible profit. By cutting trees in all diameter classes and saving many of the larger high-quality trees, the distribution of timber over the several diameter classes will be shifted from the less valuable smaller toward the more valuable larger diameters. Merchantable trees to be marked for cutting may be classified, beginning with those to be removed first, as follows:

a. Poor risks, trees unlikely to remain alive until the next cutting.

b. Trees seriously decayed or infested with beetles.

c. Overmature trees that have passed optimum development and are now deteriorating.

d. Overtopping "wolf" trees that are seriously retarding the growth of better trees.

e. Poorly formed and unthrifty trees seriously crowding the better trees in overstocked stands.

f. Poor-quality trees which, because of crook, short stem, or limbiness, will produce only growth of low quality.

g. Inferior species that have a very limited market as saw timber, such as hickory, red maple, and other hardwoods.

h. Trees approaching financial maturity, which must be cut to satisfy the financial needs of the farm owner.

5. Cut sawlogs, pulpwood, and ties, and sell them, instead of stumpage, to the highest bidder. By using his family labor for cutting each tree and portion of each tree into those products that will yield the largest net return and then selling to the highest bidder, the farmer can increase his cash income substantially above what he would receive by selling stumpage for a lump sum to the first person making an offer.

6. Limit grazing to work animals and a cow or two. Natural reproduction of both pines and hardwoods is prevented by heavy grazing.

Assuming that good management practices are adopted, many years will be required, even so, to remold the unmanaged forests of Washington Parish to the pattern desired, since the farm woodlands are generally depleted of high-quality saw-timber trees, but overstocked with undesirable hardwoods. There is a good understory of young trees, however, and with good growth, good markets, and proper attention given to the requirements of commercial operation as well as to stand improvement, good management should yield some net income from the beginning, and become increasingly profitable as yields increase in quantity and quality.

Available Technical Assistance

Even though the practices necessary for good forest management are relatively simple, will most farmers adopt them? Furthermore, is sufficient technical assistance available to them for carrying out a program of woodland management? Evidently a carefully planned educational program, including concrete demonstrations of profitable management of farm woodlands in the parish, is needed first. Following this, specific help in marking timber on the ground will be required. A limited amount of technical assistance for such a program is now available. Washington Parish is included in the Bogue Chitto-Pearl River Soil Conservation District. This District, which functions under a governing board of farmers, has authority to furnish technical forestry assistance to farmers. The Soil Conservation Service in turn gives some assistance to the District. Other public agencies authorized to aid the farmers in forest management are the State Extension Service and State Department of Conservation. The Forestry Division, Gaylord Container Corporation, at Bogalusa, also offers help to farmers in forest management.

Farmers in Washington Parish are fortunate in being able to call upon these agencies for assistance, but it must be understood that the public agencies are often limited in their activities because of insufficient personnel and funds; furthermore, they are overburdened with other duties and, in some cases, obligated to serve many other parishes (or counties) or even the whole state. In reality the available technical assistance is not adequate to meet and solve the important farm forestry problems in Washington Parish.

In comparison with what has been done in some other countries, only a beginning has been made in the United States in the application of forestry principles to the management of farm woodlands. In Sweden, for example, this problem has been handled very successfully by forest boards in each province which employ foresters and make their services available to farmers for marking timber at specified fees. These boards also provide for cooperatives to handle sales of forest products cut from farmer's woodlands. With increased funds the present agencies could undoubtedly expedite the adoption of good forestry by farmers.

Yields From Usual Farm Woodland

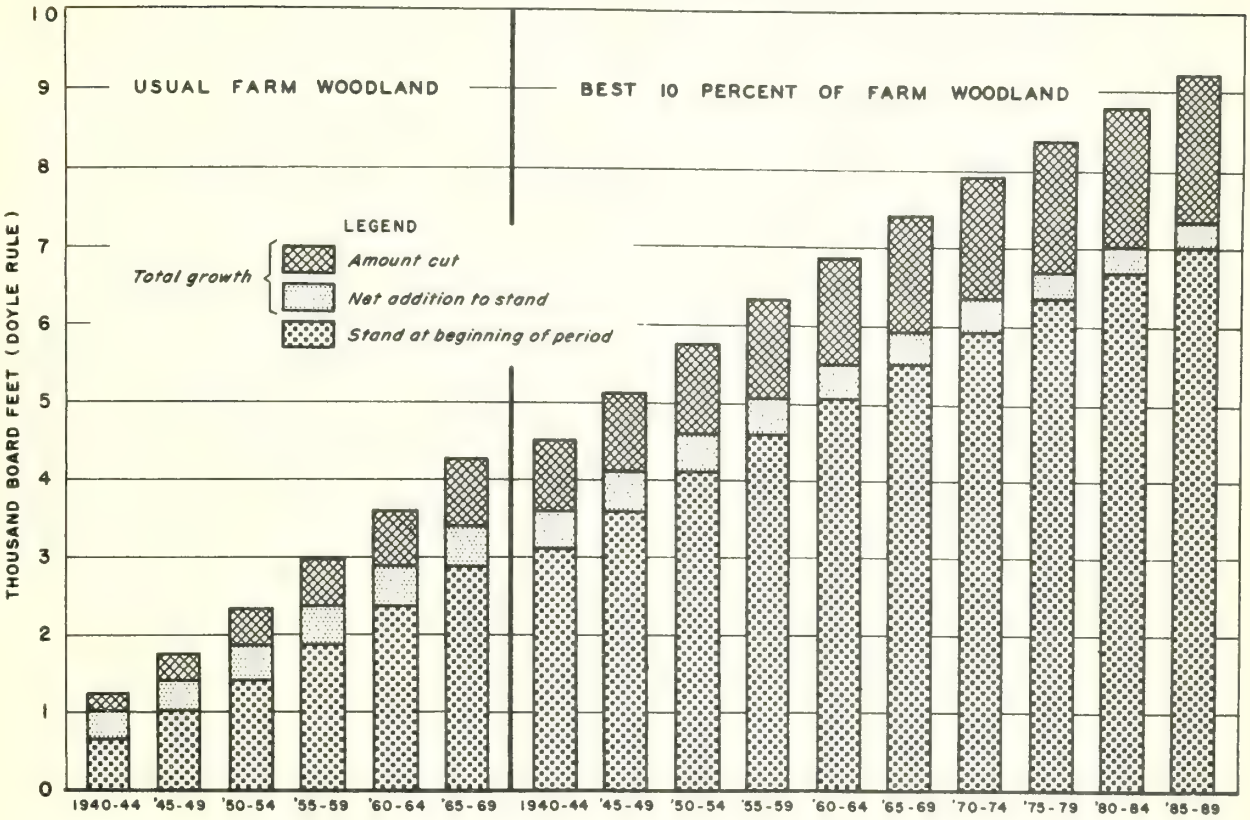
The yields that can be expected from good management of the usual farm woodlands on the one-mule and the two-mule cotton farms, consisting of 15 and 25 acres, respectively, have been estimated by 5-year periods

from the present to the year 1969. The yields for the first period, 1940 to 1944, are based on present stands, present growth rates, present requirements of fuel wood and other products for home use, and the assumption that the saw-timber cut will remove 20 percent of the saw-timber volume. Future yields are predicated on deceleration of growth as stands become more heavily stocked, but take into account the same home needs and the 20-percent cut from saw-timber growing stock during each 5-year period.

Management as applied to these stands includes those simple practices that have been set up for the direction of the farmer. The most radical change from present practice is the saving of the potential saw-timber trees for commercial lumber production, and the cutting of the bulk of the fuel wood from hardwood trees that contain no merchantable sawlogs. While some labor will be required of the farmer in fighting forest fires that threaten the woodland, or perhaps in plowing fire lines, and more effort will be needed to cut fuel wood from hard-splitting hardwood instead of easy-splitting pine, management will not entail cash outlays. Moreover, it requires only such thinning or cutting as will yield salable material or forest products that can be used on the farm.

Pine, which grows more rapidly and yields greater returns than hardwoods, should be favored in management to produce saw timber in Washington Parish. Accordingly, the heavy requirements for fuel wood must be supplied chiefly from hardwoods. Figure 2 shows, for the usual farm woodland and also for the best 10 percent of farm woodlands, the pine saw-timber yields that can be expected from good forest management. The various sections of the bars represent for each 5-year period the stand at the beginning of the period, the total growth during the period, and the yield or that part of the growth that is cut in the same period. According to the prediction, after 30 years of management the usual stand of 645 board feet per acre will be built up to 3,425 board feet per acre besides yielding six periodic cuts varying from 255 board feet for the first to 855 board feet for the sixth and totaling 3,165 board feet per acre. During the 30-year period the annual growth will increase from 125 board feet (1940-44) to 275 board feet (1965-69). After 50 years of management and selective cutting at 5-year intervals, the stand on the best 10 percent of farm woodlands, which has a present volume of 3,100 board feet per acre, should increase to 7,370 board feet besides yielding 10 cuts varying from 905 board feet for the first to 1,845 for the tenth and totaling 14,095 board feet per acre. The annual growth will increase from 285 board feet per acre (1940-44) to 433 board feet per acre (1985-89).

FIGURE 2
ESTIMATED PINE SAW-TIMBER YIELDS PER ACRE FROM MANAGED FARM WOODLANDS OF LOBLOLLY PINE-HARDWOOD TYPE IN WASHINGTON PARISH, LA., BY 5-YEAR PERIODS, 1940-89



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Tables 4 and 5 show, for the usual one-mule farm and for the two-mule farm, the cuts recommended in managing loblolly pine and hardwoods. On the one-mule farm with only 15 acres of woodland, it is necessary to appropriate all of the hardwoods and a part of the pine saw timber as well to make up the fuel-wood requirement of 9.6 cords annually, or 48 cords each 5 years. But in the 25-acre woodland on the two-mule farm some of the best hardwood trees and all pine saw-timber trees are saved for production of sawlogs, and the fuel-wood requirement of 11 cords annually, or 55 cords each 5 years, is cut from pine and hardwood top wood, defective and limby pine trees, and the poorer hardwood trees. In neither case is there any pine material in excess of fuel-wood needs that could be cut for pulpwood, or any excess volume of hardwoods that could be cut into ties. During the 30 years, the periodic cut of pine saw timber is increased from present cuts of 200 and 255 board feet per acre, respectively, on the one-mule and two-mule farms, to 855 board feet for the period 1965-69. The amount of available pine fuel wood is limited in most cases, and especially so on the one-mule farm.

Table 4.—Cuts at 5-year intervals recommended in managing loblolly pine and hardwoods on the usual one-mule farm

Period	Per acre					15-acre woodland				
	Sawlogs, pine	Fuel wood		Fence posts		Sawlogs, pine	Fuel wood		Fence posts	
		Pine	Hdwd.	Pine	Hdwd.		Pine	Hdwd.	Pine	Hdwd.
	Bd.ft. 1/	Cords		Number		Bd.ft. 1/	Cords		Number	
1940-44	200	0.30	2.90	10	10	3,000	4.50	43.50	150	150
1945-49	325	.33	2.87	10	10	4,875	5.00	43.00	150	150
1950-54	375	.35	2.85	5	15	5,625	5.25	42.75	75	225
1955-59	595	.40	2.80	5	15	8,925	6.00	42.00	75	225
1960-64	725	.45	2.75	5	15	10,875	6.75	41.25	75	225
1965-69	855	.50	2.70	5	15	12,825	7.50	40.50	75	225

1/ Doyle rule.

Table 5.—Cuts at 5-year intervals recommended in managing loblolly pine and hardwoods on the usual two-mule farm

Period	Per acre						25-acre woodland					
	Sawlogs		Fuel wood		Fence posts		Sawlogs		Fuel wood		Fence posts	
	Pine	Hdwd.	Pine	Hdwd.	Pine	Hdwd.	Pine	Hdwd.	Pine	Hdwd.	Pine	Hdwd.
	Bd.ft. 1/		Cords		Number		Bd.ft. 1/		Cords		Number	
1940-44	255	50	0.20	2.00	2	10	6,375	1,250	5.00	50.00	50	250
1945-49	360	55	.30	1.90	2	10	9,000	1,375	7.50	47.50	50	250
1950-54	375	65	.35	1.85	2	10	9,375	1,625	8.75	46.25	50	250
1955-59	595	65	.40	1.80	2	10	14,875	1,625	10.00	45.00	50	250
1960-64	725	70	.45	1.75	2	10	18,125	1,750	11.25	43.75	50	250
1965-69	855	75	.50	1.70	2	10	21,375	1,875	12.50	42.50	50	250

1/ Doyle rule.

Incomes From Usual Farm Woodland

In tables 6 through 9 values have been assigned to the cuts from farm woodlands. Incomes for all periods are based on market outlets and prices in effect early in 1940. Prices later in 1940 were considerably higher but may have been abnormal because of requirements of the defense program. Future yields of saw timber will undoubtedly consist of higher-grade timber that should have a greater value than present yields, but in order to be conservative the present value has been used for yields of all periods. In order to show the cash income, the products that are sold have been separated from those that are used on the farm. Since the farmer can more readily sell sawlogs at the site after the trees have been felled and bucked, the value of this labor is shown in the tables. Values, including stumpage and labor, have also been set up for fuel wood and fence posts used on the farm. As the farmer is not fully employed in other farm enterprises, it is very desirable that he himself should perform as much of the labor as possible in his woods operations. It would also be desirable for the farmer to haul the logs to the sawmill, but usually he does not possess a truck or a wagon suitable for this purpose.

Comparison of tables 6 and 7 makes it plain that even under management the larger part of the wood production on the one-mule farm must be used to satisfy household and farm needs. The estimated value of the wood and posts that will be used annually on the farm is $22.20, if only stumpage and labor are included, but comes to $43.20 when delivered sale prices of $4 per cord and $0.08 per post are applied. The present periodic cash income of $21.00 for the one-mule farm, or an average per year of $4.20, is not very impressive, but this can be increased more than fourfold after 30 years of management. The two-mule farm (tables 8 and 9) shows a present periodic cash income of $52.12, or $10.42 annually, and a future periodic income of $160.88, or $32.18 annually, after 30 years of management. The estimated value of the wood used annually on the farm is $25 considering stumpage and labor, or $48.80 computed at sale price. A study of these results must impress the reader with the penalty the farmers are paying for overcutting their farm woodlands.

Because these total returns are small, farm woodland management may not seem very important. A comparison of incomes from unmanaged, overcut, and mistreated farm woodlands with the incomes from managed farm woodlands, however, brings out striking differences. The operator of the one-mule farm at present sells practically no forest products for cash; on the contrary he must purchase annually, or obtain from some other source, 15 percent of his fuel-wood requirement of 9.6 cords (1.4 cords), and one-third of the required 60 fence posts (20 posts). If he bought these products delivered, they would cost about as follows:

1.4 cords fuel wood at $4.00	$5.60
20 posts (heart oak) at .08	1.60
Total	$7.20

The two-mule farm operator also sells only a limited quantity of forest products for cash, though the farm woodland makes him self-sufficient at present in respect to household and farm needs. Cruises on both one- and two-mule farms indicate that woodlands are going from bad to worse and that in the future more and more of the home needs must come from outside sources.

Table 6.—Cash income (in dollars) from periodic cuts of saw timber recommended in managing loblolly pine and hardwoods on the usual one-mule farm

Period	Per acre					15-acre woodland				
	Stumpage 1/		Labor 2/	Total	Average per year	Stumpage 1/		Labor 2/	Total	Average per year
	Pine	Hardwoods				Pine	Hardwoods			
1940-44	1.20	..	0.20	1.40	0.28	18.00	..	3.00	21.00	4.20
1945-49	1.95	..	.32	2.27	.45	29.25	..	4.88	34.13	6.83
1950-54	2.25	..	.38	2.63	.53	33.75	..	5.62	39.37	7.87
1955-59	3.57	..	.60	4.17	.83	53.55	..	8.92	62.47	12.49
1960-64	4.35	..	.72	5.07	1.01	65.25	..	10.88	76.13	15.23
1965-69	5.13	..	.86	5.99	1.20	76.95	..	12.82	89.77	17.95

1/ Stumpage: Pine at $6 per M feet, hardwoods at $5 per M feet (Doyle rule).
2/ $1 value per M feet added for felling and bucking into logs.

Table 7.—Value (in dollars) of periodic cuts of forest products used on the usual one-mule farm in addition to products sold

Period	Per acre								15-acre woodland							
	Fuel wood			Fence posts			Total	Average per year	Fuel wood			Fence posts			Total	Average per year
	Stumpage 1/	Labor 2/	Total	Stumpage 3/	Labor 4/	Total			Stumpage 1/	Labor 2/	Total	Stumpage 3/	Labor 4/	Total		
Each period, 1940-44 to 1965-69	1.60	4.80	6.40	0.40	0.60	1.00	7.40	1.48	24.00	72.00	96.00	6.00	9.00	15.00	111.00	22.20

1/ Stumpage at $0.50 per cord (4' x 4' x 8').
2/ $1.50 value per cord added for cutting and hauling fuel wood to house.
3/ Stumpage at $0.02 per post.
4/ $0.03 value per post added for cutting and hauling to field.

Table 8.—Cash income (in dollars) from periodic cuts of saw timber recommended in managing loblolly pine and hardwoods on the usual two-mule farm

Period	Per acre					25-acre woodland				
	Stumpage 1/		Labor 2/	Total	Average per year	Stumpage 1/		Labor 2/	Total	Average per year
	Pine	Hardwoods				Pine	Hardwoods			
1940-44	1.53	0.25	0.30	2.08	0.42	38.25	6.25	7.62	52.12	10.42
1945-49	2.16	.28	.42	2.86	.57	54.00	6.88	10.38	71.26	14.25
1950-54	2.25	.32	.44	3.01	.60	56.25	8.12	11.00	75.37	15.07
1955-59	3.57	.32	.66	4.55	.91	89.25	8.12	16.50	113.87	22.77
1960-64	4.35	.35	.80	5.50	1.10	108.75	8.75	19.88	137.38	27.48
1965-69	5.13	.38	.93	6.44	1.29	128.25	9.38	23.25	160.88	32.18

1/ Stumpage: pine at $6 per M feet, hardwoods at $5 per M feet (Doyle rule).
2/ $1 value per M feet added for felling and bucking into logs.

Table 9.—Value (in dollars) of periodic cuts of forest products used on the usual two-mule farm in addition to products sold

Period	Per acre								25-acre woodland							
	Fuel wood			Fence posts			Total	Average per year	Fuel wood			Fence posts			Total	Average per year
	Stumpage 1/	Labor 2/	Total	Stumpage 3/	Labor 4/	Total			Stumpage 1/	Labor 2/	Total	Stumpage 3/	Labor 4/	Total		
Each period, 1940-44 to 1965-69	1.10	3.30	4.40	0.24	0.36	0.60	5.00	1.00	27.50	82.50	110.00	6.00	9.00	15.00	125.00	25.00

1/ Stumpage at $0.50 per cord (4' x 4' x 8').
2/ $1.50 value per cord added for cutting and hauling fuel wood to house.
3/ Stumpage at $0.02 per post.
4/ $0.03 value per post added for cutting and hauling to field.

In contrast to this situation, the one-mule farmer, by properly managing his 15 acres of woodland, can produce all of his home needs and thus save the cash outlay of $7.20. In addition, he can realize a cash income of $21 in the first 5 years from sale of sawlogs, and increasing amounts in later periods as stands are built up to a better-stocked condition. The two-mule farmer with 25 acres of woodland can obtain, in addition to home needs, a cash income of $52.12 in the first 5 years and increasing periodic cash incomes thereafter. Although the total value of products sold plus products used on the farm is not large, it is of real weight to the farmer who has no woodland and who must buy fuel wood and fence posts out of his small net cash income from crops, averaging about $150 on the one-mule farm and $250 on the two-mule farm. Furthermore, when it is considered that only a few days of labor are actually spent in growing and harvesting the forest products, the returns take on added significance, and it may properly be asked why the farmer should not increase his woodland acreage.

Yields and Income From Better-stocked Stands

In order to show the advantages of better-stocked stands, the probable yields from management of loblolly pine and hardwoods on 25 acres of the best 10 percent of farm woodlands were estimated for ten consecutive 5-year periods in the future. From this better stand of pine, it would be possible during each 5-year period to cut and sell for cash pulpwood as well as sawlogs. Pulpwood is cut from tops of saw-timber trees and also from defective and limby trees removed to improve the stand, and is sold to the contractors who furnish pulp mills with pulpwood. The volume of hardwoods in such a stand, however, is considerably less than that in the usual farm woodland, and it would not be feasible to save any of the hardwood trees for sawlogs, since the fuel-wood requirements are greater than total hardwood growth. The recommended cuts of various products are given in table 10 on a per-acre basis, together with volumes for the 25-acre woodland. Values have also been computed for these products, as was done in the case of the usual farm woodland, and the results are given in tables 11 and 12. Table 11 shows that after 50 years of management the present periodic net cash income of $164.37, averaging $32.87 annually, can be increased to a periodic income of $344.24, averaging $68.85 annually. The annual net cash income from other farm enterprises on the two-mule farms approximates $250; therefore the farm forestry income during the first 5-year period adds about 13 percent to it and during the tenth 5-year period adds about 28 percent. Perhaps it should be repeated that in order to keep the estimates conservative, and in order to provide for unexpected reverses, the value per thousand feet of saw timber is held at current figures, although the timber and other forest products marketed after some years of management are certain to be of considerably higher quality and larger size than the average timber now being cut and sold in the parish.

Adjustment in Size of Woodland on Two-mule Cotton Farm and Probable Income

The low incomes to be expected from 15- or 25-acre understocked farm woodlands, or even the probable incomes from better-stocked farm woodlands, represent only a modest advance toward improving the general farm economy. The possibility of increasing the size of the woodland and thus substan-

Table 10.—Cuts at 5-year intervals recommended in managing loblolly pine and hardwoods on best 10 percent of farm woodlands

Period	Per acre						25-acre woodland					
	Saw-logs, pine	Pulp-wood, pine	Fuel wood		Fence posts		Saw-logs, pine	Pulp-wood, pine	Fuel wood		Fence posts	
			Pine	Hard-woods	Pine	Hard-woods			Pine	Hard-woods	Pine	Hard-woods
	Board feet 1/	Units 2/	--Cords--		Number		Board feet 1/	Units 2/	Cords		Number	
1940-44	905	0.16	0.50	1.70	2	10	22,625	4.00	12.50	42.50	50	250
1945-49	1,030	.22	.50	1.70	2	10	25,750	5.50	12.50	42.50	50	250
1950-54	1,155	.27	.50	1.70	2	10	28,875	6.75	12.50	42.50	50	250
1955-59	1,270	.32	.50	1.70	2	10	31,750	8.00	12.50	42.50	50	250
1960-64	1,380	.37	.50	1.70	2	10	34,500	9.25	12.50	42.50	50	250
1965-69	1,485	.42	.50	1.70	2	10	37,125	10.50	12.50	42.50	50	250
1970-74	1,585	.46	.50	1.70	2	10	39,625	11.50	12.50	42.50	50	250
1975-79	1,675	.50	.50	1.70	2	10	41,875	12.50	12.50	42.50	50	250
1980-84	1,765	.54	.50	1.70	2	10	44,125	13.50	12.50	42.50	50	250
1985-89	1,845	.57	.50	1.70	2	10	46,125	14.25	12.50	42.50	50	250

1/ Doyle rule.
2/ Unit = a rick of wood (4' x 5' x 8').

Table 11.—Cash income (in dollars) from periodic cuts recommended in managing loblolly pine and hardwoods on best 10 percent of farm woodlands

Period	Per acre								25-acre woodland							
	Sawlogs			Pulpwood			Total both products	Average per year	Sawlogs			Pulpwood			Total both products	Average per year
	Pine 1/ stumpage	Labor 2/	Total	Pine 3/ stumpage	Labor 4/	Total			Pine 1/ stumpage	Labor 2/	Total	Pine 3/ stumpage	Labor 4/	Total		
1940-44	5.43	0.90	6.33	0.08	0.16	0.24	6.57	1.31	135.75	22.62	158.37	2.00	4.00	6.00	164.37	32.87
1945-49	6.18	1.03	7.21	.11	.22	.33	7.54	1.51	154.50	25.75	180.25	2.75	5.50	8.25	188.50	37.70
1950-54	6.93	1.16	8.09	.14	.27	.41	8.50	1.70	173.25	28.88	202.13	3.38	6.75	10.13	212.26	42.45
1955-59	7.62	1.27	8.89	.16	.32	.48	9.37	1.87	190.50	31.75	222.25	4.00	8.00	12.00	234.25	46.85
1960-64	8.28	1.38	9.66	.18	.37	.55	10.21	2.04	207.00	34.50	241.50	4.62	9.25	13.87	255.37	51.07
1965-69	8.91	1.48	10.39	.21	.42	.63	11.02	2.20	222.75	37.12	259.87	5.25	10.50	15.75	275.62	55.12
1970-74	9.51	1.58	11.09	.23	.46	.69	11.78	2.36	237.75	39.62	277.37	5.75	11.50	17.25	294.62	58.92
1975-79	10.05	1.68	11.73	.25	.50	.75	12.48	2.50	251.25	41.88	293.13	6.25	12.50	18.75	311.88	62.38
1980-84	10.59	1.76	12.35	.27	.54	.81	13.16	2.63	264.75	44.12	308.87	6.75	13.50	20.25	329.12	65.82
1985-89	11.07	1.84	12.91	.28	.57	.85	13.76	2.75	276.75	46.12	322.87	7.12	14.25	21.37	344.24	68.85

1/ Sawlog stumpage: Pine at $6 per M feet, hardwoods at $5 per M feet (Doyle rule).
2/ $1 value per M feet added for felling and bucking into logs.
3/ Pulpwood stumpage at $0.50 per unit (4' x 5' x 8').
4/ $1 value per unit added for cutting and stacking pulpwood.

Table 12.—Value (in dollars) of periodic cut of forest products used on the best 10 percent of farm woodlands in addition to products sold

Period	Per acre								25-acre woodland							
	Fuel wood			Fence posts			Total both products	Average per year	Fuel wood			Fence posts			Total both products	Average per year
	Stumpage 1/	Labor 2/	Total	Stumpage 3/	Labor 4/	Total			Stumpage 1/	Labor 2/	Total	Stumpage 3/	Labor 4/	Total		
Each period, 1940-44 to 1985-89	1.10	3.30	4.40	0.24	0.36	0.60	5.00	1.00	27.50	82.50	110.00	6.00	9.00	15.00	125.00	25.00

1/ Stumpage at $0.50 per cord (4' x 4' x 8').
2/ $1.50 value per cord added for cutting and hauling fuel wood to house.
3/ Stumpage at $0.02 per post.
4/ $0.03 value per post added for cutting and hauling to field.

tially supplementing the income from other farm enterprises is worthy of consideration. The size to which this woodland might be increased would be limited by the following factors:

1. Area of woodland that can be purchased for a reasonable price.
2. Financial ability of the farmer to purchase such woodland.
3. Amount of family labor not now utilized for other farm enterprises and available for management of farm woodland.

There are approximately 200,000 acres of nonfarm land in the parish. A large part of this is woodland in corporate and other private ownership, and very probably a considerable part of this could be purchased if a reasonable price could be paid for it. The farmer, however, does not have cash with which to buy, and any recommendation of such a program is wishful and impractical unless the Government provides credit facilities. During a 12-months period a two-mule cotton farmer has 145 man-days of family labor unemployed in any farm enterprise. Of this total, 76 days occur during November, December, January, and February, and the time could very well be used for management of the farm woodland.

The right-hand columns of table 13 show estimates of the annual labor requirements for cutting and managing a farm woodland of 200 acres with a stand similar to that found on the best 10 percent of the farm woodlands. About 64 man-days are required annually to cut the forest products. In addition, it is estimated, 3 days will be required for fire protection, including the building of fire lines; 2 days will be required to mark the timber to be cut; and 3 days will be required for supervising the sales and scaling the products before they are removed by the purchaser. This makes a total of about 72 man-days, which is well within the amount of time available for enterprises other than those now pursued on the farm. In most cases, however, the woodlands purchased would be similar to those on the usual farm and, with much smaller cuts, the time required for harvesting would be much less until the stand could be built up.

Table 13 also gives the volume and value of the recommended annual cuts of sawlogs, pulpwood, ties, fence posts, and fuel wood during the next 5 years, for 200 acres of the best 10 percent of the farm woodlands. Both stumpage and the value of labor in cutting these products are included, but the value that would be added by hauling these products to market has not been included because the farmer probably would not have the use of a truck or wagon suitable for this purpose. Table 13 shows a total annual cash income of $329.30 from sale of sawlogs, pulpwood, and ties, and an additional value of $45 for fence posts and fuel wood used annually on the farm. This is more than the farmer now receives from crop and livestock production. Such an income would greatly improve the financial position of the farmer, since it involves no additional expense for labor and equipment not now available for other farm operations. The only additional cost beyond those of the present farm woodland would be taxes on the approximately 70 acres which are in excess of the 160-acre homestead now exempt from taxes under Louisiana statutes, and interest on the investment in the woodland. Taxes would probably run between 10 and 20 cents per acre, and timberland would probably have a value of $10 to $20 per acre, depending on the location and the volume and quality of timber.

Table 13.—Volume and value of recommended annual cuts and annual labor requirements in cutting and managing loblolly pine and hardwoods on 200 acres of best 10 percent of farm woodlands

Product	Volume and unit	Value			Labor requirements	
		Stumpage	Labor	Total	Per unit	Total
		---	Dollars	---	Man-days	
Forest products sold for cash:						
Sawlogs 1/						
Pine	36.2 M bd.ft.	217.20	36.20	253.40	0.500	18.1
Hardwoods	2.6 M bd.ft.	13.00	2.60	15.60	.500	1.3
Pulpwood 2/						
Pine	16.2 units	8.10	16.20	24.30	.667	10.8
Ties 3/						
Hardwoods	120 ties	18.00	18.00	36.00	.100	12.0
Total		256.30	73.00	329.30		42.2
Forest products used on the farm:						
Fence posts 4/						
Hardwoods	100 posts	2.00	3.00	5.00	0.020	2.0
Fuel wood 5/						
Pine	4 cords	2.00	6.00	8.00	1.000	4.0
Hardwoods	16 cords	8.00	24.00	32.00	1.000	16.0
Total		12.00	33.00	45.00		22.0
Total cutting forest products						64.2
Building fire lines						3.0
Marking timber to be cut						2.0
Supervising sales, scaling						3.0
Total cutting and managing						72.2

1/ Stumpage: Pine $6 per M board feet, hardwoods $5 per M board feet, Doyle rule; $1 value per M board feet added for felling and bucking into logs.

2/ Stumpage $0.50 per unit (4' x 5' x 8'); $1 value per unit added for cutting and stacking pulpwood.

3/ Stumpage $0.15 per tie; $0.15 value per tie added for tie hacking.

4/ Stumpage $0.02 per post; $0.03 value per post added for cutting and hauling to field.

5/ Stumpage $0.50 per cord; $1.50 per cord added for cutting and hauling to house.

Providing woodlands of this size for all the two-mule cotton farms would require the addition of approximately 73,000 acres of woodland. If the stands on this area were built up to the stocking now found on the best 10 percent of the farms, a net cash return of approximately $137,000 annually could be realized. A program of enlarged and more productive farm woodlands would greatly improve the general economy of the parish by (1) furnishing employment to supplement that offered by farm crop production, (2) assuring a local and cheap source of building material, and (3) creating "exchange" to pay for goods from outside the community through cash sales of forest products.

In conclusion: Probably the outstanding fact brought out in this study of the place of farm woodlands in the general farm economy is the need for larger and better-stocked woodlands. Growth of timber is rapid and market outlets and prices are satisfactory in the parish, but 15- or 25-acre woodlands cannot contribute enough income to relieve the major part of the present deficiency in farm income. This might be accomplished, however, if the area of the usual farm woodland could be increased by four to eight times. Although the Farm Credit Administration can now finance sound additions to farm areas, it is not likely that many bankable cases could be found until farm forestry is more generally understood and practiced. Another possibility is the leasing or renting of private lands by corporate or smaller owners to farmers who would manage and cut the timber on a sharecropping basis. Public ownership or leasing of forest land with some arrangement for its management on a part-time basis by farmers of the area would be still another possibility. Although farm forestry can make a distinct contribution to the problem of farm adjustment in this area, its full possibilities will not be realized until the problems of increasing farm woods acreages and effectuating good management of stands are solved.

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TAXES ON FOREST PROPERTY IN NINE SELECTED PARISHES OF LOUISIANA, 1937-40, IN NINE COUNTIES OF ALABAMA, 1937-41, AND IN SEVEN COUNTIES OF MISSISSIPPI, 1936-41

By

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Associate Forest Economist

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FOREST SERVICE

SOUTHERN FOREST EXPERIMENT STATION
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The Occasional Papers of the Southern Forest Experiment Station present information on current Southern forestry problems under investigation at the Station. In some cases these contributions were first presented as addresses to a limited group of people, and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

TAXES ON FOREST PROPERTY IN NINE SELECTED PARISHES OF LOUISIANA, 1937-40, IN NINE COUNTIES OF ALABAMA, 1937-41, AND IN SEVEN COUNTIES OF MISSISSIPPI, 1936-41

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***FIGURE I.*— COUNTIES INCLUDED IN TAX-INDEX STUDY LOUISIANA, MISSISSIPPI, ALABAMA.**

FOREWORD

This report presents recent data on ad valorem taxes on forest areas in Louisiana, Alabama, and Mississippi. It is the third[1] release in a series of progress reports, the purpose of which is to present up-to-date information on the general level of assessment and taxation of forest land in the states of the lower South. Other states will be brought within the scope of the study as rapidly as possible and annual tax data for each state will be reported.

1/ The first release (Occ. Paper No. 89 and Supplement) dealt with taxes in Mississippi for 1936-39. The second (Occ. Paper No. 99) dealt with taxes in Alabama for 1937-40, and in Mississippi for 1936-40.

PART I - LOUISIANA

The Division of Forestry, Louisiana Department of Conservation, provided cooperation in both field and office in assembling the data for the State. Information was obtained from local tax records in nine parishes (equivalent to counties in other states) selected as representative of forest cover and ownership conditions in all parts of the State (fig. 1). The ten tables for Louisiana present data on the average assessed values and average ad valorem property taxes levied for State, parish, school, and road purposes (but excluding levee, drainage, and similar special taxes) per acre of forest land and timber, for the nine parishes as a whole (table 1) and for each parish separately. The lands are classified by forest type and condition class, and the tables show also the respective annual indices, taking the average of the three years 1937-38-39 as 100.

The type and condition classification used herein was determined in place in the field and is based on a uniform system used in all southern states by the Forest Survey of the Forest Service. It is not the same as the statutory classification of rural lands for tax purposes provided by the Louisiana Code. This statutory classification was found unsuitable for the purpose of this study because the classes are broad, rather loosely defined, and do not conform in a significant way to actual stand conditions. There are also wide differences among the parishes in the interpretation of what is included in each statutory class.

Besides showing the current levels of assessment and taxation, these data give some indication of recent trends in forest taxation, and in time similar figures covering a longer period will afford a valuable measure of this trend. Obviously these figures do not reveal the taxes levied on any particular property, because there is frequently wide disparity in assessments and total tax rates among individual properties within the same parish. They do, however, afford a basis for determining whether an individual property is exceptionally favored or overburdened in regard to taxes.

Table 1.—Forest taxation data: Average of nine parishes of Louisiana 1/

Item and year	Pine			Upland hardwood	Bottomland hardwood	
	Sawlog	Under sawlog	Clear cut	Under sawlog 3/	Sawlog	Under sawlog
Average assessed value per acre	Dollars					
1937	5.00	4.42	3.22	4.39	4.93	4.20
1938	4.98	4.37	3.19	4.17	4.96	4.20
1939	4.97	4.39	3.20	4.17	4.94	4.12
1940	5.08	4.40	3.20	4.17	5.45	3.91
Index of value per acre 2/	Annual Index					
1937	100	100	101	104	100	101
1938	100	100	100	98	100	101
1939	100	100	100	98	100	99
1940	102	100	100	98	110	94
Average tax per acre	Cents					
1937	20.0	16.2	13.8	14.7	16.8	15.9
1938	19.8	15.9	14.0	13.3	16.7	15.6
1939	17.2	15.4	13.4	12.9	15.0	14.4
1940	18.4	15.5	13.7	11.9	16.8	14.0
Index of tax per acre 2/	Annual Index					
1937	105	103	101	108	104	104
1938	104	101	102	98	103	102
1939	91	97	98	95	93	94
1940	97	98	100	88	104	92

1/ Beauregard, Concordia, Iberville, Jackson, LaSalle, Richland, Sabine, Washington, and Webster Parishes.
2/ 1937-39 = 100.
3/ No upland hardwood sawlog stands were found in the selected parishes.

Table 2.—Forest taxation data: Beauregard Parish, La.

Item and year	Pine			Bottomland hardwood	
	Sawlog	Under sawlog	Clear cut	Sawlog	Under sawlog
Average assessed value per acre[1]	Dollars				
1937	2.99	2.99	2.99	2.88	2.88
1938	3.11	3.11	3.11	3.00	3.00
1939	3.11	3.11	3.11	3.00	3.00
1940	3.13	3.13	3.13	3.00	3.00
Index of value per acre[2]	Annual Index				
1937	97	97	97	97	97
1938	101	101	101	101	101
1939	101	101	101	101	101
1940	102	102	102	101	101
Average tax per acre	Cents				
1937	16.3	16.3	16.3	13.6	13.6
1938	16.1	16.1	16.1	15.2	15.2
1939	14.7	14.7	14.7	14.0	14.0
1940	14.9	14.9	14.9	14.0	14.0
Index of tax per acre[2]	Annual Index				
1937	104	104	104	95	95
1938	103	103	103	106	106
1939	94	94	94	98	98
1940	95	95	95	98	98

1/ Except for standing timber assessed as timber rights, all forest land is assessed as "cut over" irrespective of condition class of any timber occurring on it.
2/ 1937-39 = 100.

Table 3.—Forest taxation data: Concordia Parish, La.

Item and year	Bottomland hardwood	
	Sawlog	Under sawlog
Average assessed value per acre	- - - - - - - - Dollars	- - - - - - - -
1937	4.99	3.38
1938	4.99	3.38
1939	4.99	3.38
1940	4.99	3.38
Index of value per acre 1/	- - - - - - - Annual Index	- - - - - -
1937	100	100
1938	100	100
1939	100	100
1940	100	100
Average tax per acre 2/	- - - - - - - - - - Cents	- - - - - - - -
1937	18.9	11.0
1938	15.7	10.4
1939	12.1	7.6
1940	13.0	8.1
Index of tax per acre 1/	- - - - - - - Annual Index	- - - - - -
1937	121	113
1938	101	107
1939	78	78
1940	83	84

1/ 1937-39 = 100.

2/ In addition to State, Parish, and school taxes here shown, all properties except those on batture (between levee and Mississippi River) are subject to a levee tax (5.0 cents per acre plus 4 mills on assessed value) equivalent to 7.0 cents per acre on sawlog properties and 6.4 cents per acre on under-sawlog properties.

Table 4.—Forest taxation data: Iberville Parish, La.[1]

Item and year	Bottomland hardwood	
	Sawlog	Under sawlog
Average assessed value per acre	Dollars	
1937	4.32	1.70
1938	4.40	1.70
1939	4.25	1.69
1940	4.32	1.69
Index of value per acre[2]	Annual Index	
1937	100	100
1938	102	100
1939	98	99
1940	100	99
Average tax per acre	Cents	
1937	8.4	3.3
1938	8.4	3.3
1939	8.1	3.3
1940	8.4	3.4
Index of tax per acre[2]	Annual Index	
1937	101	100
1938	101	100
1939	98	100
1940	101	103

1/ In addition to State, Parish, school, and road taxes here shown, all lands in Parish pay levee taxes for the Mississippi and Atchafalaya River Districts, and a portion of the Parish (Ward 1) for the Pontchartrain District also. In addition, those lands lying in organized Drainage Districts pay a drainage tax (acreage or ad valorem depending on District).
2/ 1937-39 = 100.

Table 5.—Forest taxation data: Jackson Parish, La.

Item and year	Pine			Bottomland hardwood	
	Sawlog	Under sawlog	Clear cut	Sawlog	Under sawlog
Average assessed value per acre	Dollars				
1937	4.85	3.55	3.32	5.00	3.65
1938	4.85	3.44	3.27	5.00	3.50
1939	5.25	3.64	3.30	5.00	3.85
1940	5.25	3.64	3.30	5.00	3.85
Index of value per acre 1/	Annual Index				
1937	97	100	101	100	99
1938	97	97	99	100	95
1939	105	103	100	100	105
1940	105	103	100	100	105
Average tax per acre	Cents				
1937	17.3	12.0	12.1	20.1	10.5
1938	17.7	12.1	12.2	20.8	10.2
1939	16.9	11.6	11.0	16.6	11.3
1940	19.8	13.9	12.5	18.5	14.2
Index of tax per acre 1/	Annual Index				
1937	100	101	102	105	98
1938	102	102	103	108	95
1939	98	97	93	86	106
1940	114	117	106	96	133

1/ 1937-39 = 100.

Table 6.—Forest taxation data: LaSalle Parish, La.

Item and year	Pine			Upland hardwood	Bottomland hardwood
	Sawlog	Under sawlog	Clear cut	Under sawlog	Under sawlog
Average assessed value per acre			Dollars		
1937	4.26	3.08	2.40	2.50	3.00
1938	4.26	3.03	2.40	2.50	3.00
1939	4.26	3.03	2.40	2.50	2.50
1940	4.26	3.03	2.40	2.50	2.50
Index of value per acre 1/			Annual Index		
1937	100	101	100	100	106
1938	100	99	100	100	106
1939	100	99	100	100	88
1940	100	99	100	100	88
Average tax per acre			Cents		
1937	21.3	12.5	10.2	10.4	11.3
1938	20.1	13.0	11.2	10.2	9.8
1939	14.1	11.2	8.7	11.0	8.7
1940	13.6	10.5	8.4	8.4	8.4
Index of tax per acre 1/			Annual Index		
1937	116	102	102	99	114
1938	109	107	112	97	99
1939	76	92	87	105	88
1940	74	86	84	80	85

1/ 1937-39 = 100.

Table 7.—Forest taxation data: Richland Parish, La.

Item and year	Pine	Bottomland hardwood	
	Under sawlog	Sawlog	Under sawlog
Average assessed value per acre	Dollars		
1937	7.00	8.39	8.20
1938	7.00	8.39	8.20
1939	7.00	8.39	8.20
1940	7.00	8.39	8.20
Index of value per acre 1/	Annual Index		
1937	100	100	100
1938	100	100	100
1939	100	100	100
1940	100	100	100
Average tax per acre	Cents		
1937	21.5	29.8	33.1
1938	21.2	29.2	32.9
1939	21.2	29.9	30.4
1940	21.5	31.4	33.3
Index of tax per acre 1/	Annual Index		
1937	101	101	102
1938	100	99	102
1939	100	101	95
1940	101	106	104

1/ 1937-39 = 100.

Table 8.—Forest taxation data: Sabine Parish, La.

Item and year	Pine			Bottomland hardwood
	Sawlog	Under sawlog	Clear cut	Under sawlog
Average assessed value per acre	Dollars			
1937	4.37	3.71	3.44	4.33
1938	4.33	3.68	3.25	4.33
1939	3.88	3.68	3.25	3.87
1940	4.31	3.65	3.25	3.00
Index of value per acre 1/	Annual Index			
1937	104	101	104	104
1938	103	100	98	104
1939	93	100	98	93
1940	103	99	98	72
Average tax per acre	Cents			
1937	24.7	19.9	18.9	23.7
1938	22.7	18.0	18.4	21.6
1939	21.8	20.2	20.9	21.3
1940	24.2	19.9	21.0	15.1
Index of tax per acre 1/	Annual Index			
1937	107	103	97	107
1938	98	93	95	97
1939	94	104	108	96
1940	105	103	108	68

1/ 1937-39 = 100.

Table 9.—Forest taxation data: Washington Parish, La.

Item and year	Pine		Upland hardwood
	Under sawlog	Clear cut	Under sawlog
Average assessed value per acre		Dollars	
1937	4.08	3.94	4.17
1938	4.08	3.94	3.50
1939	4.05	3.94	3.50
1940	4.12	3.94	3.50
Index of value per acre 1/		Annual Index	
1937	100	100	112
1938	100	100	94
1939	100	100	94
1940	101	100	94
Average tax per acre		Cents	
1937	11.1	11.5	11.8
1938	11.8	12.1	9.6
1939	11.9	11.9	10.4
1940	11.8	11.7	10.1
Index of tax per acre 1/		Annual Index	
1937	96	97	111
1938	102	103	91
1939	103	101	98
1940	102	99	95

1/ 1937-39 = 100.

Table 10.—Forest taxation data: Webster Parish, La.

Item and year	Pine		Upland hardwood	Bottomland hardwood	
	Sawlog	Under sawlog	Under sawlog	Sawlog 2/	Under sawlog
Average assessed value per acre			Dollars		
1937	6.50	6.50	6.50	4.00	6.50
1938	6.50	6.22	6.50	4.00	6.50
1939	6.50	6.22	6.50	4.00	6.50
1940	6.50	6.21	6.50	7.00	5.67
Index of value per acre 1/			Annual Index		
1937	100	103	100	100	100
1938	100	99	100	100	100
1939	100	99	100	100	100
1940	100	98	100	175	87
Average tax per acre			Cents		
1937	16.9	19.9	21.9	9.9	20.5
1938	18.6	19.4	20.2	10.9	21.4
1939	16.2	16.7	17.3	9.1	18.2
1940	16.1	16.2	17.2	15.8	15.3
Index of tax per acre 1/			Annual Index		
1937	98	106	111	99	102
1938	108	104	102	109	107
1939	94	89	87	91	91
1940	94	87	87	158	76

1/ 1937-39 = 100.
2/ Based on only two properties.

PART II - ALABAMA

In Alabama, the data for 1941 assessed values and taxes in the nine counties (fig. 1) were obtained by the Division of Forestry, Alabama Department of Conservation, on the same properties used as a basis for the 1937-40 data reported in Occasional Paper No. 99. These data for 1937-41 are shown in table 11. The index base (100) is the average of the three years 1937-38-39. Because of the system of "blanket assessment" used in this State, it is not possible to derive value and tax data by forest type and condition class; hence the Alabama data represent the average values and taxes for forest land irrespective of class in the nine counties as a whole and for each county separately.

As in Louisiana, these data do not reveal the tax on any particular property, although there is less disparity in Alabama than in Louisiana between the county average and the average tax on any individual property in that county. This situation arises from the fact that millage rates are uniform throughout each county, and, with few exceptions, throughout the State, a condition which does not obtain in Louisiana. By constitutional amendment, Alabama has set 21 mills per dollar as the maximum composite tax rate of all taxing districts, with minor exceptions in a few counties.

Table 11.—Forest taxation data for nine selected counties of Alabama, with group averages, 1937-41

Item and year	Counties									Average1/
	Barbour	Blount	Butler	Choctaw	Colbert	Coosa	Escambia	Jackson	Tuscaloosa	
Average assessed value per acre	Dollars									
1937	2.90	2.89	3.50	4.66	2.70	2.53	4.04	1.32	3.04	3.06
1938	2.90	2.76	3.42	4.16	2.45	2.46	4.06	1.32	2.93	2.94
1939	2.90	2.78	3.11	4.09	2.41	2.51	4.03	1.32	2.87	2.89
1940	2.90	2.71	3.22	3.90	2.26	2.86	3.91	1.32	2.71	2.87
1941	2.96	2.75	3.53	3.87	2.33	2.70	3.93	1.57	2.69	2.93
Index of value per acre2/	Annual Index									
1937	100	103	105	108	107	101	100	100	103	103
1938	100	98	102	97	97	99	100	100	99	99
1939	100	99	93	95	96	100	100	100	97	98
1940	100	96	96	91	90	114	97	100	92	97
1941	102	98	106	90	92	108	97	119	91	99
Average tax per acre	Cents									
1937	6.8	6.1	7.4	9.8	5.7	5.3	8.5	2.8	6.4	6.5
1938	6.8	5.8	7.2	8.7	5.1	5.2	8.5	2.8	6.2	6.3
1939	6.5	5.8	6.5	8.6	5.0	5.3	8.5	2.8	6.0	6.1
1940	6.5	5.7	6.8	8.2	4.7	6.0	8.2	2.8	5.7	6.1
1941	7.0	5.8	7.4	8.1	4.9	5.7	8.3	3.3	5.6	6.2
Index of tax per acre2/	Annual Index									
1937	101	103	106	109	108	100	100	100	103	103
1938	101	98	103	97	97	98	100	100	100	100
1939	97	98	93	96	95	100	100	100	97	97
1940	97	97	97	91	89	113	96	100	92	97
1941	104	98	106	90	92	108	98	118	90	98

1/ Unweighted mean of nine counties.
2/ 1937-39 = 100.

PART III - MISSISSIPPI

The 1941 data for Mississippi were obtained from local tax rolls for the same properties used as a basis for the 1936-40 data reported in Occasional Papers Nos. 89 and 99. These data, comparable in scope and applicability to those for the other two States, are shown for the seven counties (fig. 1) as a whole (table 12) and for each county separately (tables 13-19). The properties are classified by forest type and condition class, and also shown are the respective annual indices, taking the average of the three years 1936-37-38 as 100.

In 1940, Mississippi exempted standing timber of every kind from all ad valorem taxes, and imposed a severance tax of 3 percent on the value of all forest products, the value to be computed as of the time and place of severance (Chap. 114, Laws of 1940). In the following tables, data on "average tax per acre" of "sawlog" properties of each forest type include the taxes on such standing timber as was assessed thereon for the years 1936-39. The taxes shown for "sawlog" properties for 1940-41, however, are those on the land only, since timber was exempt. In Holmes, Marion, and Quitman Counties, however, no timber has been assessed on any sample property during the entire period covered by this survey. In none of the seven counties has any upland hardwood timber been assessed during this period. The "average assessed value" data for all years relate to land only. These facts should be considered in evaluating trends in taxation shown by the Mississippi tables.

It is recognized also that the classification By forest type and condition class has little or no significance under proper administration of the tax law cited previously. It is retained in those tables for two reasons: (1) because of its significance in earlier years, and (2) to show that, whereas the present law supposes that all forest land will be assessed as bare land irrespective of any timber values present, actual practice is still to assess "sawlog" lands at a higher value than other classes of land. In individual cases, of course, higher assessments on such lands may properly reflect higher actual values, but the evidence shown in these tables (all assessed values shown are of land only for all years) is that the new law (in force during 1940-41) has had no effect on altering a long-established practice of assessing the land itself at a higher level if it bore merchantable timber. It seems unlikely that such assessment is justified in every county selected for study. One effect of such assessment, of course, is to obviate, at least in part, the benefits designed by the Legislature to flow from the 1940 forest tax law.

Not included in the taxes shown are those imposed by levee and drainage districts in the Delta (see Occasional Paper No. 89 for areas included in these districts), nor taxes (generally two cents per acre) levied in certain counties for cooperative forest fire control.

Table 12.--Forest taxation data: Average for seven counties of Mississippi[1]

Item and year	Pine			Upland hardwood		Bottomland hardwood	
	Sawlog	Under sawlog	Clear cut	Sawlog	Under sawlog	Sawlog	Under sawlog
Average assessed value per acre[2]	Dollars						
1936	3.41	2.88	2.77	3.19	2.92	3.48	3.23
1937	3.41	2.88	2.77	3.19	2.92	3.48	3.23
1938	3.00	2.77	2.66	3.11	2.80	3.32	3.14
1939	3.00	2.77	2.66	3.11	2.80	3.32	3.14
1940	3.41	2.86	2.90	3.31	3.16	3.67	3.39
1941	3.50	2.86	2.90	3.31	3.17	3.67	3.39
Index of value per acre[3]	Annual Index						
1936	104	101	101	101	101	101	101
1937	104	101	101	101	101	101	101
1938	92	98	97	98	97	97	98
1939	92	98	97	98	97	97	98
1940	104	101	106	105	110	107	106
1941	107	101	106	105	110	107	106
Average tax per acre	Cents						
1936	24.2	16.6	16.5	19.8	16.8	23.2	18.0
1937	22.2	14.9	14.8	16.6	15.0	20.9	16.2
1938	21.2	14.4	14.3	17.2	14.6	20.8	16.8
1939	22.2	15.0	14.9	17.5	15.2	21.0	16.9
1940	20.5	16.3	16.8	20.0	18.0	19.5	18.4
1941	19.5	15.1	15.1	18.0	16.9	18.6	17.6
Index of tax per acre[3]	Annual Index						
1936	108	108	109	111	108	107	106
1937	99	97	97	93	97	97	95
1938	94	94	94	96	94	96	99
1939	99	98	98	98	98	97	99
1940	91	107	111	112	116	90	108
1941	87	99	99	101	109	86	104

1/ Alcorn, George, Holmes, Marion, Newton, Quitman, and Webster.
2/ Assessment is biennial. Change in value from 1940 to 1941 in pine-sawlog and upland hardwood-under sawlog classes is result of reassessment of certain properties following changes of ownership, and subdivision.
3/ 1936-38 = 100.

Table 13.--Forest taxation data: Alcorn County, Miss.

Item and year	Pine			Upland hardwood		Bottomland hardwood	
	Sawlog	Under sawlog	Clear cut	Sawlog	Under sawlog	Sawlog	Under sawlog
Average assessed value per acre 1/	Dollars						
1936	3.86	2.19	1.50	4.62	3.62	4.27	3.75
1937	3.86	2.19	1.50	4.62	3.62	4.27	3.75
1938	2.73	2.48	1.62	4.62	3.27	3.90	3.38
1939	2.73	2.48	1.62	4.62	3.27	3.90	3.38
1940	3.72	1.87	1.67	4.52	3.46	4.22	3.29
1941	3/4.26	1.87	1.67	4.52	3/3.50	4.22	3.29
Index of value per acre 2/	Annual Index						
1936	111	96	97	100	103	103	103
1937	111	96	97	100	103	103	103
1938	78	108	105	100	93	94	93
1939	78	108	105	100	93	94	93
1940	107	82	108	98	99	102	91
1941	122	82	108	98	100	102	91
Average tax per acre	Cents						
1936	22.3	10.0	7.2	26.2	18.6	26.8	19.0
1937	20.0	8.7	6.3	21.0	15.8	24.3	16.1
1938	15.0	10.3	7.1	21.7	15.2	27.2	15.7
1939	15.4	11.2	7.4	21.0	15.8	27.4	16.3
1940	22.9	8.9	8.6	23.2	17.7	25.6	17.2
1941	24.7	8.5	8.4	21.6	17.2	24.4	16.6
Index of tax per acre 3/	Annual Index						
1936	117	103	104	114	113	103	112
1937	105	90	91	91	96	93	95
1938	79	106	103	94	92	104	93
1939	81	115	107	91	96	105	96
1940	120	91	125	101	107	98	102
1941	129	88	122	94	104	93	98

1/ Assessment is biennial.
2/ 1936-38 = 100.
3/ Change from 1940 is result of reassessment of subdivided property after change of ownership.

Table 14.--Forest taxation data: George County, Miss.

Item and year	Pine			Upland hardwood	Bottomland hardwood	
	Sawlog	Under sawlog	Clear cut	Under sawlog	Sawlog	Under sawlog
Average assessed value per acre 1/	Dollars					
1936	3.50	3.29	3.03	3.05	3.10	2.96
1937	3.50	3.29	3.03	3.05	3.10	2.96
1938	3.50	3.12	2.95	3.01	3.00	2.99
1939	3.50	3.12	2.95	3.01	3.00	2.99
1940	4.00	3.70	3.68	3.43	3.50	3.79
1941	4.00	3.70	3.68	3.43	3.50	3.79
Index of value per acre 2/	Annual Index					
1936	100	102	101	100	101	100
1937	100	102	101	100	101	100
1938	100	97	98	99	98	101
1939	100	97	98	99	98	101
1940	114	115	123	113	114	128
1941	114	115	123	113	114	128
Average tax per acre	Cents					
1936	20.9	16.6	15.0	15.6	17.8	15.4
1937	20.1	14.9	13.5	13.9	15.6	14.0
1938	21.4	14.3	13.2	13.5	14.3	14.0
1939	23.8	15.2	14.3	14.4	15.8	15.1
1940	21.6	20.0	19.5	18.3	17.8	20.0
1941	20.9	17.8	17.7	16.2	16.0	18.8
Index of tax per acre 2/	Annual Index					
1936	100	108	108	109	112	106
1937	97	97	97	97	97	97
1938	103	93	95	94	92	97
1939	114	99	103	101	98	104
1940	104	131	140	128	112	138
1941	100	116	127	113	101	130

1/ Assessment is biennial.
2/ 1936-38 = 100.

Table 15.--Forest taxation data: Holmes County, Mississippi

Item and year	Pine			Upland hardwood		Bottomland hardwood	
	Sawlog	Under sawlog	Clear cut	Sawlog	Under sawlog	Sawlog	Under sawlog
Average assessed value per acre 1/	Dollars						
1936	2.83	2.47	2.41	2.28	2.53	4.38	4.08
1937	2.83	2.47	2.41	2.28	2.53	4.38	4.08
1938	2.78	2.38	2.32	2.37	2.63	4.36	4.16
1939	2.78	2.38	2.32	2.37	2.63	4.36	4.16
1940	3.09	2.72	2.55	2.39	2.83	4.66	4.23
1941	3.09	2.72	2.55	2.39	2.83	4.66	4.23
Index of value per acre 2/	Annual Index						
1936	101	101	101	99	99	100	99
1937	101	101	101	99	99	100	99
1938	99	98	97	103	103	100	101
1939	99	98	97	103	103	100	101
1940	110	111	107	103	111	107	103
1941	110	111	107	103	111	107	103
Average tax per acre	Cents						
1936	13.3	11.4	12.7	12.4	12.8	22.6	22.3
1937	13.6	11.6	12.2	11.8	12.9	21.7	21.6
1938	13.9	11.6	12.3	13.0	14.0	23.5	24.2
1939	14.0	11.8	12.7	13.1	14.0	23.1	24.1
1940	15.7	13.5	13.8	13.4	15.2	25.0	24.3
1941	15.0	12.6	11.4	12.5	14.8	25.7	24.2
Index of tax per acre 2/	Annual Index						
1936	98	99	102	100	97	100	98
1937	100	101	98	95	98	96	95
1938	102	101	99	105	106	104	107
1939	103	103	102	106	106	102	106
1940	115	117	111	108	115	111	107
1941	110	110	92	101	112	114	107

1/ Assessment is biennial.
2/ 1936-38 = 100.

Table 16.—Forest taxation data: Marion County, Miss.

Item and year	Pine			Bottomland hardwood	
	Sawlog	Under sawlog	Clear cut	Sawlog	Under sawlog
Average assessed value per acre[1]	Dollars				
1936	4.00	3.90	3.74	4.02	4.00
1937	4.00	3.90	3.74	4.02	4.00
1938	3.50	3.37	3.37	3.77	3.70
1939	3.50	3.37	3.37	3.77	3.70
1940	3.54	3.08	3.34	3.78	3.60
1941	3.54	3.08	3.34	3.78	3.60
Index of value per acre[2]	Annual Index				
1936	104	105	103	102	103
1937	104	105	103	102	103
1938	91	91	93	96	95
1939	91	91	93	96	95
1940	92	83	92	96	93
1941	92	83	92	96	93
Average tax per acre	Cents				
1936	23.4	22.9	21.2	20.8	21.8
1937	22.5	20.5	19.3	19.4	19.8
1938	21.9	18.0	17.5	19.0	19.8
1939	21.7	17.8	17.5	20.1	18.4
1940	22.4	16.9	17.9	18.2	17.8
1941	19.0	14.7	15.3	15.5	15.4
Index of tax per acre[2]	Annual Index				
1936	104	112	110	106	106
1937	100	100	100	98	97
1938	97	88	91	96	97
1939	96	87	91	102	90
1940	99	82	93	92	87
1941	84	72	79	79	75

1/ Assessment is biennial.
2/ 1936-38 = 100.

Table 17.—Forest taxation data: Newton County, Miss.

Item and year	Pine			Bottomland hardwood	
	Sawlog	Under sawlog	Clear cut	Sawlog	Under sawlog
Average assessed value per year[1]	Dollars				
1936	3.00	2.97	3.00	3.00	2.99
1937	3.00	2.97	3.00	3.00	2.99
1938	3.00	2.97	3.00	3.00	2.99
1939	3.00	2.97	3.00	3.00	2.99
1940	3.00	3.09	3.12	3.00	3.09
1941	3.00	3.09	3.12	3.00	3.09
Index of value per acre[2]	Annual Index				
1936	100	100	100	100	100
1937	100	100	100	100	100
1938	100	100	100	100	100
1939	100	100	100	100	100
1940	100	104	104	100	103
1941	100	104	104	100	103
Average tax per acre	Cents				
1936	21.4	18.6	18.3	35.2	18.6
1937	18.8	16.6	16.3	31.6	16.1
1938	18.8	17.1	16.3	31.4	16.2
1939	19.2	17.4	16.6	30.0	16.5
1940	17.7	18.1	17.9	15.2	17.6
1941	18.0	18.7	18.2	15.7	17.9
Index of tax per acre[2]	Annual Index				
1936	109	107	108	108	109
1937	95	95	96	97	95
1938	95	98	96	96	95
1939	97	100	98	92	97
1940	90	104	105	46	104
1941	91	107	107	48	105

1/ Assessment is biennial.
2/ 1936-38 = 100.

Table 18.--Forest taxation data: Quitman County, Miss.

Item and year	Bottomland hardwood	
	Sawlog	Under sawlog
Average assessed value per acre[1]	- - - - - - - - Dollars	- - - - - - - -
1936	2.56	2.44
1937	2.56	2.44
1938	2.59	2.60
1939	2.59	2.60
1940	3.58	2.79
1941	3.58	[3] 2.82
Index of value per acre[2]	- - - - - - Annual Index	- - - - - - -
1936	100	98
1937	100	98
1938	101	104
1939	101	104
1940	139	112
1941	139	113
Average tax per acre	- - - - - - - - Cents	- - - - - - - -
1936	12.7	11.6
1937	11.6	10.5
1938	12.5	12.7
1939	11.8	11.8
1940	14.3	11.6
1941	14.7	12.2
Index of tax per acre[2]	- - - - - - Annual Index	- - - - - -
1936	103	100
1937	94	91
1938	102	109
1939	96	102
1940	116	100
1941	120	105

1/ Assessment is biennial.
2/ 1936-38 = 100.
3/ Change from 1940 value is the result of dropping one property (not forest in 1941) from sample.

Table 19.--Forest taxation data: Webster County, Miss.

Item and year	Pine			Upland hardwood		Bottomland hardwood	
	Sawlog	Under sawlog	Clear cut	Sawlog	Under sawlog	Sawlog	Under sawlog
Average assessed value per acre 1/	Dollars						
1936	3.29	2.46	2.92	2.67	2.47	3.00	2.40
1937	3.29	2.46	2.92	2.67	2.47	3.00	2.40
1938	2.48	2.29	2.68	2.33	2.28	2.64	2.17
1939	2.48	2.29	2.68	2.33	2.28	2.64	2.17
1940	3.09	2.68	3.02	3.01	2.92	2.98	2.92
1941	3.09	2.68	3.02	3.01	2.92	2.98	2.92
Index of value per acre 2/	Annual Index						
1936	109	102	103	104	102	104	103
1937	109	102	103	104	102	104	103
1938	82	95	94	91	95	92	94
1939	82	95	94	91	95	92	94
1940	102	120	106	118	121	103	126
1941	102	120	106	118	121	103	126
Average tax per acre	Cents						
1936	43.8	19.9	24.8	20.9	20.4	26.6	17.0
1937	38.3	17.2	21.0	17.1	17.5	22.2	15.6
1938	35.7	15.4	19.2	17.0	15.5	17.0	14.9
1939	39.4	16.8	21.0	18.5	16.6	18.5	15.9
1940	22.7	20.4	23.3	23.5	20.6	20.3	20.2
1941	19.6	18.2	19.7	20.0	19.4	18.2	18.1
Index of tax per acre 2/	Annual Index						
1936	111	114	114	114	115	121	108
1937	97	98	97	93	98	101	99
1938	91	88	88	93	87	78	94
1939	100	96	97	101	93	84	101
1940	58	117	107	128	116	93	128
1941	50	104	91	109	109	83	115

1/ Assessment is biennial.
2/ 1936-38 = 100.

OCCASIONAL PAPER NO. 102

May 18, 1942

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RECOMMENDATIONS FOR KILLING SCRUB OAKS AND OTHER UNDESIRABLE TREES

By

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U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

SOUTHERN FOREST EXPERIMENT STATION
E. L. Demmon, Director
New Orleans, La.

The Occasional Papers of the Southern Forest Experiment Station present information on current southern forestry problems under investigation at the station. In some cases, these contributions were first presented as addresses to a limited group of people, and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

RECOMMENDATIONS FOR KILLING SCRUB OAKS

AND OTHER UNDESIRABLE TREES

By L. J. Dessin, Assoc. Forest Ecologist
Southern Forest Experiment Station

Summary

Three methods of killing scrub oaks were recently tested in southern Mississippi. These included: (1) Cutting trees above and below the surface of the ground, (2) Girdling the stems at the base by removing the bark and by killing the cambium and the bark with flames from a blow torch, and (3) Poisoning.

Most of the trees that were cut produced vigorous sprouts. Girdling or removing a strip of bark around the base of the tree for a distance of about one foot above ground yielded fairly satisfactory results. Although the crowns died slowly no sprouts developed from either the root collar or the stem. This method, although costly and requiring very careful work, is recommended where it is unsafe to use poison. Burning the butts of the trees with a blow torch proved too ineffective for practical use.

The most successful and cheapest method tested consisted of injecting sodium arsenite into the roots or stems of trees, through the use of a tool developed especially for this purpose. Most of the trees so treated died in a relatively short time. Caution is needed in the use of sodium arsenite. The poison is deadly to both animals and plants and should be handled with extreme care.

* * * * * * * *

On most of the forest land in the South there are many trees of no present or potential value, yet of sufficient vigor to crowd out or seriously hinder the growth of valuable trees. Such trees are as detrimental in a forest as weeds in a field of cotton or corn. In the pine lands of the Lower South the most common "weed trees" are scrub oaks, which include blackjack (*Quercus marilandica* Muench.), bluejack (*Q. cinerea* Mich.), turkey (*Q. catesbaei* Mich.) and dwarf post oaks (*Q. stellata margaretta* Sarg.). Although by no means the only weed trees, these scrub oaks are especially undesirable because of their notably vigorous and persistent sprouting following cutting or fire. Scrub oaks are also instrumental in spreading the canker-forming rust disease (*Cronartium fusiforme* (A and K) Hedg. and Hunt.), which kills or deforms the stems of southern pine seedlings, saplings, and nursery stock. One generation of this disease occurs on oak leaves, and the spores produced there are responsible for infecting young pines. Obviously, therefore, the presence of oaks in the vicinity of forest nurseries is undesirable. In the aggregate, hundreds of thousands of acres in the South are overrun with scrub oaks and other trees of little or no value. To eradicate such trees requires not merely the killing of the tops or crowns but also the prevention of sprouting, and this has generally been found difficult and expensive to accomplish. This report describes a recently developed method that is both cheap and effective. Another method that has produced fairly satisfactory results, although at a greater cost, is also discussed.

Cutting and Girdling

Various methods have been used in attempting to kill undesirable trees. If a tree is cut down, or partially cut through and bent over, sprouts usually develop. In general the smaller the tree the more numerous and vigorous are the sprouts. Scrub oaks are usually of the small sizes that sprout most prolifically. Vigorous sprouting often nullifies the benefit accomplished by removing the top of an undesirable tree.

The results of cutting scrub oaks were recently studied in southern Mississippi. A total of 410 trees were cut at a height of about one foot above ground, and 1123 trees were cut just below the root collar. The trees in both tests ranged from 2 to 4 inches in diameter at breast height. Of the trees cut above ground only 5 percent of the stumps were dead after two years, while the remaining 95 percent sprouted vigorously. Cutting below the root collar produced better results since 38 percent of the stumps showed no sprouts after two years. Mortality was about twice as great in trees cut in late autumn and in winter as in trees cut in spring and in midsummer.

Trees are sometimes killed by girdling, i.e., cutting through the vital cambium tissue between the bark and the wood in a continuous ring around the trunk. Girdling is usually effective in killing trees more than about 10 - 12 inches in diameter, but smaller trees usually produce vigorous sprouts below the girdle. The effectiveness of girdling in killing scrub oaks was recently tested in southern Mississippi. The treatments consisted of removing the bark from around the base of 93 scrub oaks to a height of about one foot above the root collar and of burning the bark at the butts of 113 scrub oaks with a blow torch. The latter treatment was designed to kill the cambium at the base of the trees. Two years later, the removal of bark at the base had resulted in the death of 51 percent of the trees so treated. Where the bark was not completely removed and narrow strips of living tissue bridged the girdle, the trees remained alive though in a very weak condition. Burning at the butt killed only 27 percent of the trees so treated. The burning proved most effective when done in winter, but the removal of bark produced best results when done in midsummer.

Poisoning

Poisons have frequently been used for killing undesirable trees, but usually have been dangerous to use or expensive to apply effectively, or both. Poisons can be used as sprays, as applications around the trunks or roots of trees, or as injections into trees. Sodium chlorate has been found effective when sprayed on sprouts arising from stumps. Owing to its inflammability, however, this poison can be used with reasonable safety only under certain limited conditions and with particular care. When applied as injections into trees sodium chlorate has been found to be ineffective. Sodium chlorate was injected into 260 trees in recent tests in southern Mississippi but only 6 percent were dead two years after treatment. Sodium arsenite has been used successfully by applying it in "basins" at the base of stumps, or in "frills" or girdles around the stem, but these methods are dangerous due to the accessibility of the poison to livestock. In general, poisoning has been more successful than either cutting or girdling in killing trees, and sodium arsenite has been found to be the most effective poison.

A new, safer, cheaper, and more effective method for using sodium arsenite has been developed recently by the Southern Forest Experiment Station. It involves applying sodium arsenite in holes punched in the stem or roots of trees with a special tool. When this poison was injected into the stems of 165 scrub oaks in southern Mississippi, 73 percent died within two months. Injection of sodium arsenite into the roots of 175 scrub oaks resulted in a mortality of 81 percent. The injections were tested at four dates (January, April, July, and November) in trees from two to six inches in diameter at breast height. Trees treated during the summer showed the highest mortality, although the differences associated with season were small.

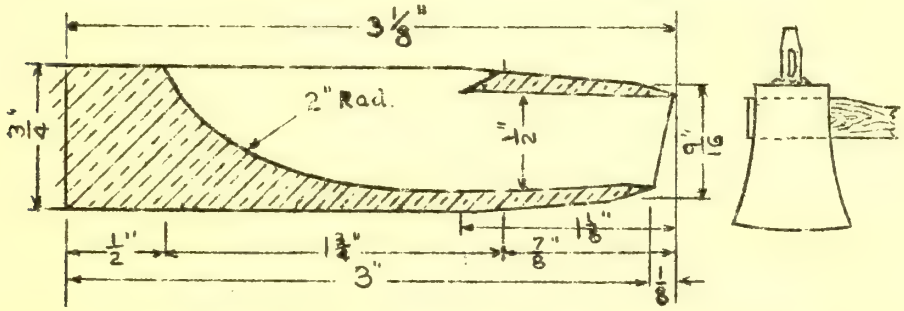

FIG. 1

Materials and Equipment Needed in Using Sodium Arsenite

The materials and equipment needed are as follows:

1. White arsenic (arsenic trioxide).
2. Caustic soda (sodium hydroxide) flakes.
3. Water.
4. A metal container (10-gallon capacity).
5. Locomotive engineer's oil can with thumb lever (one-quart capacity).
6. Leather or rubber gloves.
7. A tool for making holes in trees.

If only a few trees are to be treated, the holes can be drilled with a brace and bit, but if many trees are to be treated a special hole-punching tool developed by the Southern Forest Experiment Station is recommended. This tool consists of an ax with a special punch made from tool steel and attached to the ax head as shown in Fig. 1. The opening in the inside of the attachment is oval in shape and measures 1-3/4 inches by 1/2 inch. The cutting edge is 1/8 inch shorter at one side than at the

other to facilitate the punching of holes at an angle of about 45 degrees. The attachment is welded on the ax so that the short side is upward when the punch is driven into the tree. One stroke removes a core of wood 1/2 inch in diameter and about 1 inch long. A public-service patent for this hole-punching ax has been applied for by the Southern Forest Experiment Station. Names of manufacturers of the tool will be furnished on request.

Preparation of Sodium Arsenite

To make approximately one gallon of sodium arsenite, or enough to fill about 500 average holes, proceed as follows:

1. Weigh out 8 pounds of white arsenic powder into a metal can.
2. Weigh out 2 pounds of caustic soda flakes into the same can.
3. Thoroughly stir the two chemicals in the dry condition with a wooden paddle.
4. When the chemicals are well mixed, add 3 quarts of water very slowly while stirring the mixture, which will begin to boil soon after the water is added. When the boiling ceases the two chemicals will have formed a clear, thick, heavy solution. This is sodium arsenite, an extremely poisonous compound.

CAUTION: The poison should be prepared out of doors. Avoid breathing the fumes that develop. Wear a mask or cloth over nose and mouth during the preparation. Avoid spattering the chemicals on the skin or into the eyes.

If more poison is needed, use more chemicals and water in the proportions indicated above, i.e., for every pound of caustic soda use 4 pounds of white arsenic and 1-1/2 quarts of water.

Application of Sodium Arsenite

To apply sodium arsenite by the injection method, strike the main roots of the tree near the root collar with the hole-punching tool, or bore a hole there. Fill the hole with poison from the oil can by pressing the lever lightly with the thumb. By careful manipulation the hole can be filled with poison without spilling any of it on the tree or on the ground. It is very important to prevent spilling the poison. If any appreciable amount is spilled on the ground or on the tree, the salty taste of the sodium arsenite may attract cattle or other animals. The poison is deadly to animals as well as to plants.

The amount of poison held in a hole punched with the special tool varies from 5 to 10 cubic centimeters, depending on the force of the blow. The average hole holds about 6 cubic centimeters. The number of holes needed depends on the size of the tree. A tree up to 3 inches in diameter at breast height usually can be killed with poison placed in one hole in the root or in the stem. For each additional 2 inches in diameter an extra hole is needed, so that a 5-inch tree requires two holes, a 7-inch tree three holes, etc. The experimental results obtained to date indicate that poisoning in midsummer yields best results.

The cost of poisoning will depend on the current prices of the chemicals, the quantity in which they are purchased, and the size and distribution of the trees. On an experimental basis, scrub oaks of average size were killed at a cost of less than one cent per tree.

Precautions in Using Sodium Arsenite

Sodium arsenite is extremely poisonous and should be handled with utmost care. After using the poison the operator should wash his hands thoroughly with soap and water, and no food should be touched by the hands before they are thoroughly washed. All equipment and materials should be kept out of reach of children and animals, and should be plainly marked as to their use and contents. A container in which sodium arsenite has been kept should never be used for any other purpose.

This method of poisoning trees is recommended only for areas closed to grazing. If the method is used in grazed areas, however, livestock should first be removed and should not be permitted on the area until at least three days have elapsed following the last poison treatments. Under summer conditions the poison is absorbed by the tree in less than thirty minutes, but in winter the absorption is much slower. It is thought, however, that sodium arsenite will be completely absorbed in three days under even the most adverse weather conditions.

No definite information is yet available on the safety of using wood from poisoned trees for fuel. Until such information is available, wood from poisoned trees should not be used for fuel because arsenic may be contained in the smoke and the fumes would then be poisonous.

For further information address the Director, Southern Forest Experiment Station, New Orleans, Louisiana.

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EAST TEXAS FORESTS AND THE FUTURE

By

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U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

SOUTHERN FOREST EXPERIMENT STATION
E. L. Demmon, Director
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EAST TEXAS FORESTS AND THE FUTURE[1]

By E. L. Demmon, Director,
Southern Forest Experiment Station

Introduction

Although forest growth occurs on less than a fifth of the total land area of Texas, it represents one of the State's major natural resources. The commercial forests of Texas are confined to the eastern section of the State and the discussion here will deal primarily with that area.[2] For many years, east Texas forests have provided material for building homes, communities, railroads, churches, and schools; they have given employment to thousands of workers; in addition, they have exerted a beneficial influence in conserving rainfall and in protecting soil from excessive erosion. Today these forests are providing materials essential to the war effort of America and her Allies. Under proper management, the forests of east Texas can provide the raw materials needed for all its present forest industries and also for many additional establishments, to the greater security and prosperity of all the people. Compared with many other sections of the country, east Texas offers advantages for the maintenance of forest industries, as its soil and climate favor rapid tree growth, there are many widely used hardwood and softwood tree species native to this section, markets are at hand, and labor is abundant.

Location and Availability

After many years of forest exploitation and clearing of forest land for farms, the commercial forests of east Texas still occupy almost 11 million acres, or about 57 percent of the land area. Actually, this exceeds by 3 million acres the total acreage of the State's principal farm crop, cotton. Forests are found in every section of east Texas with the exception of the tidal marshes along the Gulf of Mexico. Road, rail, and water transportation facilities are entirely adequate. Logging operations are relatively simple; as a result of the construction of highways and improvement in motorized equipment, transportation of logs and lumber by truck has become common and is rapidly increasing in importance.

Area, Type, and Volume

According to the recently completed forest survey conducted by the U. S. Forest Service, the productive forest area of Texas, by forest type and condition, was classified as follows (for 1935):

1/ Address before the Annual Meeting of the Texas Academy of Science, at College Station, Tex., Nov. 14, 1942.

2/ Although not discussed in this paper, Texas has several other forested areas, the chief value of which lies in protection of the soil resources, preventing erosion and controlling the run-off of rain water. The more important of these forested areas are the Post Oak belt which adjoins the east Texas commercial pine region on the west; the Cedar Brakes of central Texas; the East and West Cross Timbers, extending from the Cedar Brakes northward to the Oklahoma boundary; and scattered stands of mesquite, live oak, and other species in various localities.

Forest type	Forest condition				Percent
	Old growth	Second growth	Reproduction and clear-cut	Total	
	Thousand acres				
Longleaf	128	513	290	931	9
Shortleaf-loblolly	375	5,825	126	6,326	60
Upland hardwoods	259	1,051	112	1,422	13
Bottom-land hardwoods ..	698	1,138	38	1,874	18
Total	1,460	8,527	566	10,553	100
Percent	14	81	5	100	

The total merchantable wood volume in Texas, classed either as saw timber or cordwood, on January 1, 1939, was as follows:

Tree species group	Saw timber 1/	Cordwood 2/
	Million feet b.m. (lumber tally)	Thousand cords
Pine	19,290	73,189
Hardwood (including cypress)	10,336	55,084
Total	29,626	128,273

1/ Pine 9 inches and larger, and hardwoods 13 inches and larger, in diameter, at breast height.

2/ All trees 5 inches in diameter and larger, at breast height, whether saw-timber size or under; excludes culls and hardwood tops and limbs.

These forests today are characterized by second-growth timber, much of it below the minimum size for most industrial uses. While these young forests do not have the high quality of the original old-growth stands, they are of sufficiently good quality to supply most market needs.

Current Forest Situation

What is the present situation as regards this valuable Texas resource? Although commendable progress has been made in the adoption of good forestry practices by a growing number of progressive timberland owners in east Texas, the forests as a whole are far from being in a sound condition. A recent survey by the U. S. Forest Service indicated that east Texas forests are in general understocked, producing at less than half of their potential capacity. Part of this is due to destructive timber cutting practices of the past, although even today altogether too much timber is being cut without any conscious attempt to perpetuate the forest. This is especially true of the operations of hundreds of small portable mills, the owners of which usually possess no timberland, and who generally cut any tree that will make a 2x4.

In southeast Texas there are many thousands of acres of land formerly covered by some of the finest longleaf pine in the South that now are desolate and bare stump fields; they will not bear another timber crop unless planted. Part of the present unsatisfactory forest condition also can be laid to oft-recurring fires, which in the past have destroyed untold millions of forest seedlings and reduced the growth and the quality of the remaining trees.

Adequate protection of forests from fire is one of the essentials of good forest management, yet today a considerable portion of the east Texas forest area is not under organized fire protection. With fire protection and good forest management east Texas can be assured of a maximum of forest products, expanded industries, more jobs for labor, additional revenues, and improved social conditions for its people.

Ownership or Control

According to recent estimates, about two-thirds of the forest land in east Texas is in small holdings (under 3,000 acres) mostly owned by farmers. Approximately 6 percent of the forest area is in national forests and 6,400 acres, or 6 hundredths of 1 percent, is in State forests. An undetermined area is in public ownership as a result of tax delinquency. The balance is in the hands of lumber companies, pulp and paper mills, oil companies, and in other large holdings.

Value of Forest Products

The cost or value of individual forest products varies greatly with many factors. The Census for 1939 showed that the materials produced by the primary forest-products industries in east Texas during that year were valued at more than 50 million dollars, as follows:

Forest-products industry	Value of products
	Thousands of dollars
Sawmills, veneer plants, etc. ..	27,925
Logging camps	970
Planing mills	9,314
Pulp mills	1,432
Paper mills	3,616
Paper bags	1,276
Paperboard containers	2,753
Cooperage	249
Wood preserving	8,088
Total	55,623

General Uses of Forest Products

The most important industries depending upon east Texas forests for their raw materials are those manufacturing lumber and paper, and wood preserving plants. Other important forest products include fuel wood, veneer, cooperage, poles and piling, fence posts, and railroad cross ties. The forests also support an important range livestock industry, provide a home for game animals, and afford opportunities for hunting and other recreational activities. Considerable cut-over timberland is leased for oil development. These multiple uses of forest land provide additional income while the timber crop is growing.

Texas has 2 pulp mills, 1 of which is the only one of its kind, a newsprint mill which manufactures newsprint from southern pine. The forests of east Texas support industries employing more than 21,000 laborers. According to the 1939 Census, about 15 percent of all workers employed in the State's manufacturing industries received their income directly from the preparation of forest products for the market. The wages and salaries paid by these

forest-products industries in 1939 totaled over 16 million dollars. Most of the forest industrial plants are located in small towns and in rural areas. Lumber manufacture alone accounted for most of the forest industry employment.

The number of primary forest industrial plants in east Texas, according to the most recent information available, is as follows:

Sawmills cutting 25 million bd.ft. or more annually ...	7
" " 15-25 " " " " " ...	15
" " 10-15 " " " " " ...	19
" " 5-10 " " " " " ...	28
" " 1- 5 " " " " " ...	179
" " under 1 " " " " " ...	300
Treating plants (for poles, piles, cross ties, etc.) ...	10
Veneer plants	26
Stave and heading plants (cooperage stock	5
Pulp mills (using only wood)	2
Small dimension plants	6
Miscellaneous wood-using plants	63

Production Trends

According to the U. S. Forest Service, the commodity usage of Texas forest products during recent years was as follows:

Commodity	Year			
	1935	1936	1937	1938
	-----Thousands of cords 1/------			
Lumber	1,971	2,584	2,674	2,481
Cross ties	263	343	383	223
Poles and piles	37	63	68	47
Veneer	62	66	77	84
Cooperage	21	17	18	15
Pulpwood	-	12	111	109
Miscellaneous	18	16	12	11
Fuel wood	899	861	934	934
Fence posts	58	49	54	54
Miscellaneous farm use ...	21	22	23	23
Land clearing	224	167	187	187
Total	3,574	4,200	4,541	4,168

1/ From all trees 5 inches d.b.h. and larger, and including bark.

Exports and Imports of Lumber

Recent trends of lumber exports and imports for Texas are as follows:

Item	1936	1938	1940
	Billion feet, board measure		
Lumber production 1/	.94	1.03	1.27
Lumber imports	.41	.38	.43
Total lumber distributed	1.35	1.41	1.70
Lumber used in Texas	.99	1.10	1.40
Lumber shipped out of the State	.36	.31	.30

1/ Lumber production in Texas for other recent years, in billions of feet b.m., is as follows: 1937, 1.13; 1939, 1.14; 1941, 1.33.

These figures indicate that Texas is more of a lumber importing than an exporting State. Per capita consumption of lumber in Texas in recent years was 168 bd.ft. in 1936, 180 bd.ft. in 1938, and 228 bd.ft. in 1940, very near the national average for each of these years.

Specific Uses and Byproducts

In the past, Texas has produced large quantities of lumber and other roughly manufactured wood products for its own uses, such as for building construction, and for shipment out of the State. The principal secondary wood-using industries in Texas as reported for 1940, listed on the basis of the amounts of wood used, were as follows:

Products	Wood used
	Million feet, b.m.
Boxes, baskets, crating	80.7
Sash, doors, general millwork	62.6
Furniture	15.5
Flooring	12.9
Car construction and repair	11.3
Caskets and burial boxes	6.3
Handles	5.2
All others	12.0
Total	206.5

The principal species of woods used by these secondary wood-using industries were as follows:

	Volume used, million feet b.m.
Pine, southern yellow	52.5
Pine, ponderosa	40.5
Tupelo and black gum	32.5
Gum, red	26.4
Oak	15.9
Cottonwood	14.8
Cypress	6.0
All others (using less than 5 million feet each)	17.8
Total	206.5

To take full advantage of the opportunities offered by its forests, to absorb more of its local labor, and to permit realization locally of the values of further processing, east Texas is greatly in need of additional remanufacturing plants, such as furniture factories, wood fabricating industries, plywood and plastic plants, etc., which will produce finished goods for local and national consumer markets. The recent expansion of the pulp and paper industry is an excellent example of progress in this direction.

Useful as wood is in the form in which nature provides it, science has shown the way to transformations that add greatly to its importance as a resource of our developing civilization. Although wood conversion products as yet rate far below lumber and other primary products in bulk of wood consumed, they satisfy many needs and promise to become increasingly important. A few of

the products of east Texas forests which can be utilized advantageously by manufacturing industries will be discussed in the next few paragraphs. Many of these products serve war needs and are of great importance now.

Pulp and Paper

Cellulose is the most important part of wood from the chemical-industrial standpoint. This remarkable substance is nature's framework and construction material with which are formed the walls of cells that make up the bodies of all plant life. Wood is the most abundant and compact source of this material, more than half of its substance being cellulose fiber. Wood is the principal source of many kinds of paper and pulp products, so essential to our everyday life and to the war effort. Cellulose made from wood is relatively cheap, worth currently about 4 cents per pound, far below the price of cotton, which has formerly been the principal source of pure cellulose.

With paper consumption rapidly increasing in this country and with imports of European pulp and paper shut off because of the war (before 1939, the United States imported more than half of its annual pulp and paper requirements), there may be further opportunities for growth of this industry in east Texas. This should be guided, however, by careful consideration of the quantity, quality, and availability of pulpwood, the effect on the raw material supplies required by other forest-products industries, and with due regard to factors of long-time investment. It is also contingent upon the maintenance of east Texas' marked advantages over other sections of the United States and foreign sources in regard to costs of pulpwood and other raw materials, and of the manufacturing operations.

The 2 Texas pulp mills (at Houston and Lufkin) use southern pine, the one at Houston operating by the sulphate process, where the bulk of the pulp is bleached and made into fine white papers. The pulp mill at Lufkin produces newsprint, the only plant of its kind in the entire South.

One of the most hopeful aspects for the expansion of the pulp and paper industry in east Texas and other Southern States lies in the opportunity it offers for the utilization of low-quality forest material not needed by other forest industries. East Texas has outstanding opportunities to produce pulpwood, along with continuous supplies of sawlogs and other forest products. The vast resources of hardwoods in the bottom lands of east Texas and in the Post Oak and Cross Timbers belts offer excellent possibilities for a pulp and paper industry which can utilize those species. Tests at the U. S. Forest Products Laboratory at Madison, Wis., have indicated the feasibility of using a semichemical process to convert swamp blackgum, sweetgum, oak, and other hardwoods into quality pulps, to be used alone or in mixtures, for newsprint, corrugating board, and a variety of specialty products. One southern mill now makes high-grade sulphite pulp from southern pine. Most southern pulp mills, however, use the sulphate or Kraft process.

An outstanding advantage to the east Texas pulp and paper industry is its nearness to supplies of chemicals used in the manufacturing process. Salt cake or sodium sulphate is the chief chemical raw material used in the sulphate process of digesting wood. From 150 to 450 pounds of salt cake or its equivalent per ton of finished pulp is utilized to maintain the concentration of the cooking liquor, the amount depending on the efficiencies of the washing and recovery processes. The principal supply of salt cake was formerly imported from Germany and other foreign sources but is now produced locally, from salt

and sulphur, another byproduct of this process being muriatic (hydrochloric) acid. Chlorine is the chief bleaching agent for all kinds of pulp, being utilized as such or in combination with lime as a hypochlorite. Oyster shells are occasionally used as a source of lime in the sulphate recovery process; limestone is employed ordinarily. Chemicals used in the manufacture of paper include rosin and alum (aluminum sulphate) for size, sodium silicate, glue, starch, and casein. Many of these raw materials are available in Texas or nearby States, or can be produced locally.

Rayon and Related Products

Synthetic fibers, designated in general as rayon, consist of cellulose chemically modified and spun into silklike filaments, strands, and yarns. Their production has increased markedly during the last few years, and they are particularly important now that imports of raw silk have ceased. Rayon can be produced by several different chemical processes. The raw materials commonly used have been wood pulp and cotton linters (the short lint recovered from the coatings on the cotton seed after the staple has been removed). Wood pulp makes up about 75 percent of the present production of rayon, which requires a highly purified cellulose. This is principally high-grade bleached sulphite pulp made from spruce and hemlock, but other conifers and also hardwoods have been reported as satisfactory. Seventy percent of the country's rayon production comes from the South. By modifying the processes, it is possible to produce cellophane or similar transparent sheeting used for wrapping and packaging.

Cellulose acetate, with a low inflammability, is finding wide use for moving-picture film, and by reason of its plastic properties, can be used to manufacture a great array of molded articles.

A mixture of nitric and sulphuric acids when made to react with cellulose produces nitrocellulose. When this reaction is carried to a high degree of nitration, it forms the high-explosive smokeless powder. When it is nitrated to a lesser degree this type of product may be cast into films such as photographic and motion picture and transparent sheeting in general. When combined with plasticizing agents such as camphor it may be molded into a wide variety of forms. When dissolved in solvents and produced in the form of low-viscosity cellulose nitrate it forms the most important constituent of the modern type of quick-drying lacquers for the coating of automobiles, furniture, and other surfaces requiring a hard, resistant, and durable protective coating.

Purified wood cellulose is being used increasingly for smokeless powder, plastics, lacquers, cellophane, and the like, and promises to play an even more important role in the future.

Mention should be made of lignin, one of the major components of wood and a byproduct of the pulp industry. Lignin compounds form a large proportion of pulpmill waste and contribute to stream pollution. Lignin is a potential source of plastics, not only by itself but also in combination with other materials. As such it offers possibilities for important new industrial developments.

Hardwood Distillation Products

The distillation of wood is an ancient industry, one of the chief products being charcoal. This is the carbonaceous residue left when wood is burned without enough air to insure its reduction to ashes. Chemists have isolated more than 60 individual chemical compounds from the vapors evolved in the distillation of hardwoods, but not all of these are worth purifying or are present in sufficient amount to be valuable. The principal products besides charcoal are methanol (wood alcohol), acetate of lime or acetic acid, and related chemicals. In recent years, synthetic methanol and synthetic acetic acid have seriously narrowed the market for both of these products from wood.

This is one of the few forest industries not concerned with large size or superior quality of the wood it consumes. Only 2 destructive hardwood plants are operating in the South at present, 1 in Arkansas and 1 in Tennessee.

Comparison of Growth and Drain

From a previous table (page 4) it will be noted that lumber makes up more than half the material removed annually from east Texas forests. The relation of growth to drain in east Texas forests during several recent years was as follows:

	1935	1936	1937	1938
Commodity drain, in M cords	3,574	4,200	4,541	4,168
Net increment in growing stock, in M cords ...	5,995	6,215	6,357	6,527
Relation of drain to growth, in percent	60	68	71	64
Commodity drain, in millions of board feet ...	1,352	1,582	1,646	1,474
Net increment in growing stock, in millions of board feet	1,822	1,848	1,881	1,917
Relation of drain to growth, in percent	75	86	88	77

Total growth expressed in cords or board feet exceeded total drain during the 1935-38 period. Most of the sawlog cutting, however, was concentrated on large, high-quality trees, with a resulting decrease in quality and value of the remaining growing stock. The war has increased the demands for all forest commodities, and east Texas' forests now are supplying increased quantities of lumber, boxboards, paper, and other essential war materials, with the result that the current drain on its timber supplies is undoubtedly greater than the amount being replaced through growth. This is an entirely justifiable measure in the present crisis and it is fortunate that these timber supplies are available for the emergency. Nevertheless, it is important that this great natural asset, so essential to our permanent national defense and economic security, be protected adequately and utilized wisely, with the least possible waste. President Roosevelt, in his message to Congress on January 7, 1942, recognized such need when he said: "It is necessary in wartime to conserve natural resources and keep in repair our national plant. We cannot afford waste or destruction, for we must continue to think of the good of future generations of Americans." The contribution of east Texas forests in the period of readjustment that will follow the war will be highly important, not only in providing the raw materials needed for a huge reconstruction program at home and abroad, but also in supplying outlets for labor and industry within the State.

Future Markets

East Texas forest resources are sufficiently ample, if managed properly, to furnish adequate quantities of forest products for the State's needs and leave a substantial balance for shipment outside the State. The proximity of the lumber markets of the Middle West and the excellent facilities for shipment to the Atlantic seaboard, to Latin America and other world markets, provide east Texas with many favorable outlets for its forest products.

Planning for the Future

Everyone will agree as to the necessity of producing all the forest raw materials needed for the war effort, even though this results in a temporary overcutting. However, this should be done with a minimum of waste and under methods which will properly use and conserve forest-productive capacity rather than tear it down. If east Texas forests are to yield maximum, sustained returns to the landowners and serve the best interests of the public, a number of actions should be taken now, the owners and public each contributing a share. This is the time to lay sound plans for a forestry program to meet the problems and adjustments of the post-war period. Later on will be too late.

Of major importance is to see that all east Texas forest lands receive adequate protection from fire, insects, and disease. This is particularly urgent as a war measure, to avoid critical losses during this emergency. It will mean that additional public and private funds must be made available for such protection purposes.

To obtain a crop of timber by good forest protection and management is of no permanent value if the productivity of the forest is subsequently curtailed or impaired by improper or destructive cutting. Therefore it seems essential, in the public interest, that timber harvesting practices on private lands be placed under some form of public control. This could be done by adopting cutting standards that will prevent unnecessary destruction and deterioration of the forest resource, thus assuring that forest lands will be kept reasonably productive and that watershed protection values will not be impaired. Such requirements are relatively simple; in fact, many private owners who are now practicing good forestry are doubtless already conforming to such proposed cutting standards. What happens to Texas forests is a matter of concern to all of the country, which uses considerable lumber and other forest materials produced in Texas. Therefore it is a primary responsibility of the Federal Government to see that necessary actions are taken to protect this vital natural resource.

Other measures needed to improve the present forestry situation in east Texas include:

1. Acquisition and management by communities, counties, the State, or the Federal Government of forest lands of vital public interest, such as important watersheds or devastated areas and those submarginal for private forest management. On Federally acquired lands a proportion of the current income is returned to the local governments in lieu of taxes. The great bulk of the forestry job, however, still will remain with the private owners.

2. Much more needs to be done in the way of forest extension, education, demonstration, and technical guidance to obtain proper forest management and marketing of timber products.

3. Much additional information is needed to provide the scientific basis for good forestry practice and this can best be obtained through forest research; due to insufficient funds, present forest research efforts are short of actual needs.

4. Obstacles to stabilized ownership necessary for long-time forest management should be removed or ameliorated—among those are discriminatory taxes, unfair freight rates, and unfavorable credit and insurance facilities.

Conclusion

East Texas forests, which occupy almost 6 out of every 10 acres of its land area, are of inestimable value in the nation's war effort. They also can and should play a major role in the post-war future of this great commonwealth. Forests differ from most other natural resources in that they can be fully used, and, at the same time, be made to increase in volume and value. Forestry progress in east Texas is being implemented by the work of the Texas Forest Service, the State extension forester, and by the research and administrative groups of the U. S. Forest Service. All of these agencies are working towards obtaining good forestry practices in east Texas forests.

A fully developed forestry program for this region will bring increased forest-products industries, more jobs for labor, additional revenues, and improved social conditions. The public agencies and the landowners share the responsibility of taking whatever actions may be necessary to assure that this great natural resource is utilized wisely and contributes fully to the greatest good of all the people.

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LOUISIANA'S FORESTS AND THE FUTURE

By

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U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

SOUTHERN FOREST EXPERIMENT STATION
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The Occasional Papers of the Southern Forest Experiment Station present information on current southern forestry problems under investigation at the Station. In some cases, these contributions were first presented as addresses to a limited group of people, and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

LOUISIANA'S FORESTS AND THE FUTURE[1/]

By E. L. Demmon, Director,
Southern Forest Experiment Station

Introduction

Louisiana's forests are one of her major natural resources. Since Colonial days, these forests have provided material for building homes, communities, railroads, churches, and schools; they have given employment to thousands of workers; in addition, they have exerted a beneficial influence in conserving rainfall and in protecting soil from excessive erosion. Today these forests are providing many of the materials essential to the war effort of America and her Allies. Under proper management, Louisiana's forests can provide the raw materials needed for all its present forest industries and also for many additional establishments, to the greater security and prosperity of all its people. Compared with other sections of the country, Louisiana offers many advantages for the maintenance of forest industries, as its soil and climate favor rapid tree growth, there are many widely used hardwood and softwood tree species native to the State, markets are nearby, and labor is abundant.

Location and Availability

After more than a century of forest exploitation and clearing of forest land for farms, Louisiana's forest land still occupies more than 16 million acres, or 56 percent of the total land area of the State. Actually, this amounts to more than 13 times the acreage planted to cotton, the principal farm crop. Forests are found in every section of the State with the exception of the tidal marshes along the Gulf of Mexico, and in the prairies of the south-central region. All parts of the State have adequate road, rail, or water transportation facilities. Logging operations are relatively simple; as a result of the construction of highways and improvement in motorized equipment, transportation of logs and lumber by truck has become common and is rapidly increasing in importance.

Area, Type, and Volume

According to the recently completed forest survey conducted by the U. S. Forest Service, the forest area of Louisiana, by forest type and condition, was classified as follows (for 1934-35):

Forest type	Forest condition				Percent
	Old growth	Second growth	Reproduction and clear-cut	Total	
	Thousand acres				
Longleaf	200	830	1,528	2,558	16
Shortleaf-loblolly	249	4,622	203	5,074	31
Upland hardwoods	184	679	72	935	6
Bottom-land hardwoods ..	2,709	4,555	363	7,627	47
Total	3,342	10,686	2,166	16,194	100
Percent	21	66	13	100	

1/ Address before the Louisiana Section, American Society of Civil Engineers, at New Orleans, La., Oct. 5, 1942.

The total merchantable wood volume in Louisiana, classed as either saw timber or cordwood on January 1, 1939, was as follows:

Tree species group	Saw timber 1/	Cordwood 2/
	Million feet B.M. (lumber tally)	Thousand cords
Pine	15,109	52,948
Hardwood (incl. cypress) ...	26,479	120,301
Total	41,588	173,249

1/ Pine 9 inches and larger, and hardwoods 13 inches and larger, in diameter, at breast height.

2/ All trees 5 inches in diameter and larger, at breast height, whether saw-timber size or under; excludes culls and hardwood tops and limbs.

Of all the States in the Lower South, Louisiana ranks second only to Georgia in total quantity of its saw timber. Louisiana has more hardwood timber than any other State in the Nation, and ranks near the top in softwoods. These forests today are characterized by second-growth timber, much of it below the minimum size for most industrial uses. While these young forests do not have the high quality of the original old-growth stands, they are of sufficiently good quality to supply most market needs.

Current Forest Situation

What is the present situation as regards this valuable Louisiana resource? Although commendable progress has been made in the adoption of good forestry practices by a growing number of progressive timber landowners in the State, the forests as a whole are far from being in a sound condition. A recent survey by the U. S. Forest Service indicated that Louisiana's forests are in general greatly understocked, producing at less than half of their potential capacity. Part of this is due to destructive timber cutting practices of the past, although even today altogether too much timber is being cut without any conscious attempt to perpetuate the forest. This is especially true of the operations of hundreds of small portable mills, the owners of which usually possess no timberland, and who generally cut any tree that will make a 2x4.

In southwest Louisiana there are nearly a million acres of land formerly covered by some of the finest longleaf pine in the South that now are desolate and bare stump fields; they will not bear another timber crop unless planted. Part of the present unsatisfactory forest condition also can be laid to oft-recurring fires, which in the past have destroyed untold millions of forest seedlings and reduced the growth and the quality of the remaining trees. Adequate protection of forests from fire is essential to good forest management, yet today only about one-third of Louisiana's forests is under organized fire protection. With fire protection and good forest management Louisiana can be assured of a maximum of forest products, expanded industries, more jobs for labor, additional revenues, and improved social conditions for the people of the State.

Ownership or Control

According to recent estimates, about 21 percent of the forest land in Louisiana is a part of farms. This represents an average of 23 acres of woodland per farm, comprising about one-third of all the land in farm ownership.

Approximately 4 percent of the State's forest area is in national forests and about ½ of 1 percent is in State forests, parks, and game refuges. About 8 percent is in State ownership as a result of tax delinquency. The balance, or about two-thirds of the total, is in the hands of lumber companies, pulp and paper mills, and other nonfarm private owners.

Value of Forest Products

The cost or value of individual forest products varies greatly with many factors. The Census for 1939 showed that the materials produced by the forest-products industries in Louisiana during that year were valued at close to 100 million dollars, as follows:

Forest-product industry	Value of products
	Thousands of dollars
Sawmills, veneer plants, etc.	33,319
Logging camps	412
Planing mills	6,245
Pulp mills	13,817
Paper mills	25,650
Paper bags	5,744
Paperboard containers	4,538
Cooperage	838
Wood preserving	4,837
Wood naval stores	2,678 (est.)
Gum naval stores	40 (est.)
Total	98,118

General Uses of Forest Products

The most important industries depending upon Louisiana forests for their raw materials are those manufacturing lumber and paper. Other important forest products include fuel wood, veneer, cooperage, poles and piling, fence posts, railroad cross ties, and naval stores (turpentine and rosin). The forests also support an important range livestock industry, provide a home for game animals, and afford opportunities for hunting and other recreational activities. Considerable cut-over timberland is leased for oil development. These multiple uses of forest land provide additional income while the timber crop is growing.

In recent years, Louisiana has led the Nation in the production of hardwood lumber. It leads the South in number of large sawmills. Its 7 pulp mills place it first among the Southern States in consumption of pulpwood, and in the United States as a whole, only Washington and Maine surpass it. It leads the South also in the production of paper and paperboard. The forests of Louisiana support industries employing more labor than any other except farming. According to the 1939 Census, somewhat over one-third of all workers employed in Louisiana' manufacturing industries received their income directly from the preparation of forest products for the market. The wages and salaries paid by the forest-products industries in 1939 totaled almost 24 million dollars. Most of the forest industrial plants are located in small towns and in rural areas. Lumber manufacture alone accounted for about 50 percent of forest industry employment. The pulp and paper industry furnished nearly half as much employment as the lumber industry.

The number of primary forest industrial plants in Louisiana in 1940, according to the U. S. Forest Service, was as follows:

Sawmills cutting 25 million bd.ft. or more annually	3
" " 15-25 " " " " "	11
" " 10-15 " " " " "	21
" " 5-10 " " " " "	35
" " 1- 5 " " " " "	88
" " under 1 " " " " "	407
Treating plants (for poles, piles, cross ties, etc.)	12
Veneer plants	14
Stave and heading plants (cooperage stock)	27
Pulp mills (using only wood)	7
Small dimension plants	4
Miscellaneous wood-using plants	18
Wood naval stores (destructive steam solvents)	3
Gum naval stores (turpentine stills)	4

Production Trends

According to the U. S. Forest Service, the commodity usage of Louisiana's forests during recent years was as follows:

Commodity	Year			
	1935	1936	1937	1938
	------Thousands of cords 1/-----			
Lumber	2,912	3,179	3,324	2,278
Cross ties	223	304	435	251
Poles and piles	54	61	98	69
Veneer	103	126	125	105
Cooperage	106	137	173	125
Pulpwood 2/	468	470	398	387
Miscellaneous	16	17	12	14
Fuel wood	1,245	1,248	1,260	1,260
Fence posts	65	63	66	66
Miscellaneous farm use	57	59	59	59
Land clearing	567	311	312	313
Total	5,816	5,975	6,262	4,927

1/ From all trees 5 inches d.b.h. and larger, and including bark.

2/ By 1941, pulpwood drain had reached 783,000 cords.

Exports and Imports of Lumber

Recent trends of lumber exports and imports for Louisiana are as follows:

Item	1936	1938	1940
	Billion feet, board measure		
Lumber production 1/	1.25	.95	1.08
Lumber imports	.11	.15	.08
Total lumber distributed	1.36	1.10	1.16
Lumber used in Louisiana 2/	.51	.48	.50
Lumber exports: To other States	.73	.50	.56
Lumber exports: To foreign countries ...	.12	.12	.10

1/ Lumber production in Louisiana for other recent years, in billions of feet B.M., is as follows: 1937, 1.36; 1939, 1.04; 1941, 1.17.

2/ Per capita lumber consumption in Louisiana exceeds the national average by about 50 percent.

These figures indicate that Louisiana is primarily a lumber exporting State, shipping out more than half the lumber it produces.

Specific Uses and Byproducts

In the past, Louisiana has produced large quantities of lumber and other roughly manufactured wood products for its own uses, such as for building construction, and for shipment to other parts of the country and abroad. The principal secondary wood-using industries in Louisiana as reported for 1940, listed on the basis of the amounts of wood used, were as follows:

Products	Wood used	Percent of total
	Million feet, B.M.	
Flooring	153.1	52
Boxes, baskets, crating	77.7	27
Sash, doors, general millwork	33.5	11
Furniture	13.4	5
Dairy and poultry supplies	3.7	1
Woodenware and novelties	3.4	1
Car construction and repair	2.1	
Caskets and burial boxes	1.7	
Ship and boat building	1.6	3
Handles	1.0	
All others	1.7	
Total	292.9	100

The principal species of woods used by these secondary wood-using industries were as follows:

	Volume used, million feet B.M.
Oak	143.0
Pine, southern yellow	40.4
Gum, red	32.6
Cottonwood	19.4
Tupelo	15.6
Cypress	13.2
Pine, ponderosa	11.8
All others	16.9
Total	292.9

To take full advantage of the opportunities offered by its forests, to absorb more of its local labor, and to permit realization locally of the values of further processing, Louisiana is greatly in need of additional remanufacturing plants, such as furniture factories, wood fabricating industries, plywood and plastic plants, etc., which will produce finished goods for local and national consumer markets. The recent expansion of the pulp and paper industry is an excellent example of progress in this direction.

Useful as wood is in the form in which nature provides it, science has shown the way to transformations that add greatly to its importance as a resource of our developing civilization. Although wood conversion products as yet rate far below lumber and other primary products in bulk of wood consumed, they satisfy many needs and promise to become increasingly important. A few of the products

of Louisiana's forests which can be utilized advantageously by manufacturing industries will be discussed in the succeeding paragraphs. Many of these products are of great importance now as they serve war needs.

Pulp and Paper

Cellulose is the most important part of wood from the chemical-industrial standpoint. This remarkable substance is nature's framework and construction material with which are formed the walls of cells that make up the bodies of all plant life. Wood is the most abundant and compact source of this material, more than half of its substance being cellulose fiber. Wood is the principal source of many kinds of paper and pulp products, so essential to our everyday life and to the war effort. Cellulose made from wood is relatively cheap, worth currently about 4 cents per pound, far below the price of cotton, which was formerly the principal source of pure cellulose.

With normal paper consumption increasing in this country and with imports of European pulp and paper shut off because of the war (before 1939, the United States imported more than half of its annual pulp and paper requirements), there may be further opportunities for growth of this industry in Louisiana. This should be guided, however, by careful consideration of the quantity, quality, and availability of pulpwood, the effect on the raw material supplies required by other forest-products industries, and with due regard to factors of long-time investment. It is also contingent upon the maintenance of Louisiana's marked advantages over other sections of the United States and foreign sources in regard to costs of pulpwood and other raw materials, and of the manufacturing operations.

The 7 pulp mills in Louisiana (at Bogalusa, Bastrop (2), Monroe, Hodge, Springhill, and Elizabeth) use southern pine and operate by the sulphate process, the bulk of the pulp going into Kraft wrapping paper, bags, board, containers, and similar products. 1940 production of paper and paperboard in Louisiana amounted to more than 750,000 tons. Also, 2 additional Louisiana plants use pulpwood, along with other raw materials, to produce building materials.

One of the most hopeful aspects for the expansion of the pulp and paper industry in Louisiana and other Southern States lies in the opportunity it offers for the utilization of low-quality forest material not needed by other forest industries. Louisiana has outstanding opportunities to produce pulpwood, along with continuous supplies of sawlogs and other forest products. The vast resource of hardwoods in the Mississippi River Delta section of the State offer excellent possibilities for a pulp and paper industry which can utilize those species. Tests at the U. S. Forest Products Laboratory at Madison, Wis., have indicated the feasibility of using a semichemical process to convert swamp blackgum, sweetgum, and other hardwoods into quality pulps, to be used alone or in mixtures, for newsprint, corrugated board, and a variety of specialty products. In nearby Texas, newsprint has been made successfully since 1940, from southern pine, at the only mill of its kind in the South. In Florida is a mill making high-grade sulphite pulp from southern pine. Most southern pulp mills, however, use the sulphate or Kraft process, and many are now bleaching the sulphate pulp to make the lighter, higher-quality papers.

An outstanding advantage to the Louisiana pulp and paper industry is its nearness to supplies of chemicals used in the manufacturing process. Salt cake or sodium sulphate is the chief chemical raw material used in the sulphate process of digesting wood. From 150 to 450 pounds of salt cake or its equivalent per ton

of finished pulp is needed to maintain the concentration of the cooking liquor, the amount depending on the efficiencies of the washing and recovery processes. The principal supply of salt cake was formerly imported from Germany and other foreign sources but is now produced in Louisiana, from salt and sulphur. Chlorine is the chief bleaching agent for all kinds of pulp, being utilized as such or in combination with lime as a hypochlorite. Oyster shells are occasionally used as a source of lime in the sulphate recovery process; limestone is employed ordinarily. Other chemicals used in the manufacture of paper include rosin and alum (aluminum sulphate) for size, sodium silicate, glue, starch, and casein. Many of these raw materials are available in Louisiana or nearby States, or can be produced locally.

Rayon and Related Products

Synthetic fibers, designated in general as rayon, consist of cellulose chemically modified and spun into silklike filaments, strands, and yarns. Their production has increased markedly during the last few years, and they are particularly important now that imports of raw silk have ceased. Rayon can be produced by several different chemical processes. The raw materials commonly used have been wood pulp and cotton linters (the short lint recovered from the coatings on the cotton seed after the staple has been removed). Wood pulp makes up about 75 percent of the present production of rayon, which requires a highly purified cellulose. This is principally high-grade bleached sulphite pulp made from spruce and hemlock, but other conifers and also hardwoods have been reported as satisfactory. Seventy percent of the country's rayon production comes from the South. By modifying the processes, it is possible to produce cellophane or similar transparent sheeting used for wrapping and packaging.

Cellulose acetate, with a low inflammability, is finding wide use for moving-picture film, and by reason of its plastic properties, can be used to manufacture a great array of molded articles.

A mixture of nitric and sulphuric acids when made to react with cellulose produces nitrocellulose. When this reaction is carried to a high degree of nitration, it forms the high-explosive smokeless powder. When it is nitrated to a lesser degree this type of product may be cast into films such as photographic and motion picture and transparent sheeting in general. When combined with plasticizing agents such as camphor it may be molded into a wide variety of forms. When dissolved in solvents and produced in the form of low-viscosity cellulose nitrate it forms the most important constituent of the modern type of quick-drying lacquers for the coating of automobiles, furniture, and other surfaces requiring a hard, resistant, and durable protective coating.

Purified wood cellulose is being used increasingly for smokeless powder, plastics, lacquers, cellophane, and the like, and promises to play an even more important role in the future.

Mention should be made of lignin, one of the major components of wood and a byproduct of the pulp industry. Lignin compounds form a large proportion of pulpmill waste and contribute to stream pollution. Lignin is a potential source of plastics, not only by itself but also in combination with other materials. As such it offers possibilities for important new industrial developments.

Hardwood Distillation Products

The distillation of wood is an ancient industry, one of the chief products being charcoal. This is the carbonaceous residue left when wood is burned without enough air to insure its reduction to ashes. Chemists have isolated more than 60 individual chemical compounds from the vapors evolved in the distillation of hardwoods, but not all of these are worth purifying or are present in sufficient amount to be valuable. The principal products besides charcoal are methanol (wood alcohol), acetate of lime or acetic acid, and related chemicals. In recent years, synthetic methanol and synthetic acetic acid have seriously narrowed the market for both of these products from wood. However, New Orleans is the largest user of charcoal of any community in the United States, affording a ready outlet for this commodity.

This is one of the few forest industries not concerned with large size or superior quality of the wood it consumes. Only 2 destructive hardwood plants are operating in the South at present, 1 in Arkansas and 1 in Tennessee.

Naval Stores (Turpentine and Rosin)

One of the oldest and most important forest industries in the Lower South is the naval stores industry. This industry, which produces practically all of the rosin and turpentine used in this country and in normal times a large part of that used abroad, is centered in southern Georgia and northern Florida. Nearly two-thirds of the rosin and turpentine produced is derived from the gum of living trees (longleaf and slash pines); the distillation of resinous stumps and heartwood accounts for most of the remainder. Although the decade 1930-40 was a period of relatively poor demand, excessive production, and low prices, there is at present an impending shortage of these materials because of their importance as war materials.

Louisiana is in a transition period so far as the production of gum naval stores is concerned. Past production came from old-growth stands of longleaf pine prior to harvesting operations. These old-growth stands are almost entirely cut out now and the second-growth stands which are replacing them are for the most part not yet of sufficient size to justify turpentining operations. Furthermore, many longleaf stands have been replaced by loblolly and shortleaf pines which do not yield turpentine in commercial quantities. The outlook for an extensive gum naval stores industry in Louisiana in the immediate future is not particularly bright.

There are 3 wood naval stores distillation plants operating in Louisiana (Covington, DeQuincy, New Orleans), producing rosin, turpentine, and pine oil. In 1937, these consumed 121,000 tons of pine distillation wood, of which about four-fifths was stump wood and the remainder top wood. There was at that time over 7 million tons of longleaf pine stumps in south Louisiana available for use by this industry, indicating considerable room for expansion if all the stump wood is to be utilized.

The production of sulphate turpentine and rosin by pulp mills in Louisiana has increased with the expansion of this industry.

Spanish Moss

Harvesting, curing, and marketing Spanish moss (Tillandsia usneoides) has been a profitable industry in Louisiana forests for more than half a century.

Spanish moss is a true epiphyte (air plant) and grows in quantities upon cypress, oaks, and other trees in the bottom lands, especially in the swamps in the southern part of the State. It is commercially important because of its tough fibrous tissue, which makes it valuable for upholstery, mattresses, and similar products. The moss is gathered by inhabitants of the swamps as a part-time activity associated with fishing, trapping, subsistence farming, etc. In some cases, moss-gathering rights on tracts of timber are purchased, but most moss is harvested without obtaining definite permission from the landowner. After the moss is gathered and air cured, it is sold to a moss gin for processing and resale to manufacturers. There are currently more than 30 moss gins operating in the State, and the total value of the product is estimated to exceed 1 million dollars annually. The moss reproduces rapidly and there is no evidence of any decrease in the supply.

Comparison of Growth and Drain

From a previous table (page 4) it will be noted that lumber makes up about half the material removed annually from Louisiana's forests. The relation of growth to drain in Louisiana's forests during several recent years was as follows:

	1935	1936	1937	1938
Commodity drain, in M cords	5,816	5,975	6,262	4,927
Net increment in growing stock, in M cords ...	6,746	6,844	6,960	7,163
Relation of drain to growth, in percent	86	87	90	69
Commodity drain, in millions of board feet ...	2,108	2,208	2,333	1,729
Net increment in growing stock, in millions of board feet	1,888	1,902	1,922	1,968
Relation of drain to growth, in percent	112	116	121	88

Although total growth expressed in cords exceeded total drain during the 1935-38 period, the opposite was true of the saw-timber component of the forest (pines 9 inches and larger in diameter, breast height, and hardwoods 13 inches and larger), except in 1938. This overcutting was concentrated on the large, high-quality trees, with a resulting decrease in quality and value of the remaining growing stock. Far more serious, however, was the forest survey finding that Louisiana forests were growing at less than half of their productive capacity.

The war has increased the demands for all forest commodities, and Louisiana's forests now are supplying increased quantities of lumber, boxboards, paper, and other essential war materials, with the result that the current drain on the State's saw-timber supplies is greater than the amount being replaced through growth. This is an entirely justifiable measure in the present crisis and it is fortunate that Louisiana has timber supplies available for the emergency. Nevertheless, it is important that this great natural asset, so essential to our permanent national defense and economic security, be protected adequately and utilized wisely, with the least possible waste. President Roosevelt, in his message to Congress on January 7, 1942, recognized such need when he said: "It is necessary in wartime to conserve natural resources and keep in repair our national plant. We cannot afford waste or destruction, for we must continue to think of the good of future generations of Americans." The contribution of Louisiana's forests in the period of readjustment that will follow the war will be highly important, not only in providing the raw materials needed for a huge reconstruction program at home and abroad, but also in supplying outlets for labor and industry within the State.

Forest Products Trade Possibilities with Latin America

In considering the future of Louisiana forests, an important factor to be taken into account is the opportunity for interchange of forest products with our Latin American neighbors. Future development of inter-American relations will depend in large part on the intelligent utilization of natural resources, one of the most important of which is the forest resources. About 42 percent of the total land area of the 20 Latin American republics is forest land, covering over 2 billion acres and exceeding 3 times the forest area of the United States. Nearly half of this is in Brazil, comprising the most extensive solid body of forest in the world. The major part of Latin American forests are tropical forests, made up of hundreds of species of trees, principally hardwoods. The better known of these are cabinet woods, including mahogany, Spanish cedar, and rosewood, but many others are valuable for construction and other purposes. In spite of the abundance of Latin America's forest resources, forest products thus far have not figured very prominently in the foreign trade of these countries. The principal forest products have been tanning extracts, cabinet woods, nuts, carnauba or vegetable wax, rubber, and chicle. Forest products imports into Latin America have had a value about double that of their forest products exports. The largest items of import have been paper and wood pulp; the next largest, lumber. Before the war a considerable proportion of Latin American imports of lumber and pulp and paper came from the Scandinavian countries. These items now are supplied from North America, and much is shipped from the port of New Orleans.

Consumption of wood in Latin America has been excessively low. Whereas the principal forest resource is hardwoods, the principal need is for softwoods for lumber. Domestic consumption of lumber and construction timber in Latin American countries in 1937 ranged from 10 board feet per capita in Brazil and Bolivia to more than 100 board feet per capita in Argentina and Chile, as contrasted with an average of 137 board feet per capita in the United States. Per capita consumption of paper ranged from 5 to 48 pounds in the various Latin American countries in 1937, whereas in the United States it was 245 pounds.

The forest resources of Latin America are not contributing anywhere near what they should to the national economy of the several republics. Contributing to the lack of exploitation of Latin American timber resources are inadequacy of domestic transportation, lack of skilled labor, lack of capital for exploitation, lack of markets, and lack of scientific knowledge of management and utilization of the woods available. The slight use of wood in local construction in the Latin American countries is largely attributable to custom, to low incomes, and to low standards of living. There are many latent possibilities for expansion of domestic consumption as well as of exports and imports. Increased exports of forest products to North America would have a beneficial effect on the foreign trade situation of the Latin American countries, would increase their purchasing power, and would decrease their dependence on trade with Europe. The United States could undoubtedly absorb many Latin American forest products without adverse effect on our own forest industries and forest land development. There is need for closer cooperation between the Americas in developing a two-way trade in forest products that will be mutually profitable, but which will not result in exploitation of our friends and neighbors to the south. Improvement in inter-American trade relations will greatly increase the economic and political solidarity of this hemisphere.

Future Markets

Louisiana's forest resources are sufficiently ample, if managed properly, to continue it as an exporting State, and at the same time furnish adequate quantities of forest products for its own needs. Over 95 percent of the lumber imported into Louisiana comes from adjacent States. Most lumber exports go to northern and eastern States, with substantial amounts going to Latin American countries. The proximity of the lumber markets of the Middle West and the excellent facilities for shipment through New Orleans to the Atlantic seaboard, to Latin America and other world markets, provide Louisiana with many favorable outlets for its forest products.

Planning for the Future

Everyone will agree as to the necessity of producing all the forest raw materials needed for the war effort, even though this results in a temporary overcutting. However, this should be done with a minimum of waste and under methods which will properly use and conserve forest-productive capacity rather than tear it down. If Louisiana's forests are to yield maximum, sustained returns to the landowners and serve the best interests of the public, a number of actions should be taken now, the owners and public each contributing a share. This is the time to lay sound plans for a forestry program to meet the problems and adjustments of the post-war period. Later on will be too late.

One important step is to see that all Louisiana's forest lands receive adequate protection from fire, insects, and disease. This is particularly urgent at this time if critical losses are to be avoided during the war emergency. It will mean that additional public and private funds be made available for such protection purposes.

To obtain a crop of timber by good forest protection and management is of no permanent value if the productivity of the forest is subsequently curtailed or impaired by improper or destructive cutting. Therefore it is essential, in the public interest, that timber harvesting practices on private lands be placed under public control. This could be done by setting up cutting standards that will prevent unnecessary destruction and deterioration of the forest resource, thus assuring that forest lands will be kept reasonably productive and that watershed protection values will not be impaired. Such requirements are relatively simple; in fact, private owners who are now practicing good forestry are doubtless already exceeding any cutting standards that might be adopted. What happens to Louisiana's forests is a matter of concern to all the country, inasmuch as Louisiana sends more lumber and other forest products out of the State than it uses locally. It is a public responsibility to see that necessary actions are taken to prevent further destruction of this vital natural resource.

Other measures needed to improve the present forestry situation in Louisiana include:

1. Acquisition and management by communities, parishes, the State, or the Federal Government of forest lands of vital public interest, such as important watersheds or devastated areas, and lands which private owners cannot reasonably be expected to manage properly. The great bulk of the forestry job, however, still will remain with the private owners.

2. Much more needs to be done in the way of forest extension, education, demonstration, and technical guidance relative to proper forest management and marketing of timber products.

3. Much additional information is needed to provide the scientific basis for good forestry practice and this can best be obtained through forest research; due to insufficient funds, present forest research efforts are short of actual needs.

4. Obstacles to stabilized ownership necessary for long-time forest management should be removed or ameliorated—among those are discriminatory taxes, unfair freight rates, and unfavorable credit and insurance facilities.

Conclusion

Louisiana's forests, which occupy almost 6 out of every 10 acres of its land area, are of inestimable value in the war effort. They also can and should play a major role in the post-war future of this great commonwealth. Forests differ from most other natural resources in that they can be fully used, and, at the same time, be made to increase in volume and value. Forestry progress in Louisiana is being implemented by the work of the State forestry organization, the State extension forester, the forestry school at Louisiana State University, and by the research and administrative groups of the U. S. Forest Service. All of these agencies are working towards obtaining good forestry practices on all the forest land in the State.

A fully developed forestry program for the State will bring increased forest-products industries, more jobs for labor, additional revenues, and improved social conditions. The public agencies and the landowners share the responsibility of taking the necessary action to assure that this great natural resource is utilized wisely and contributes fully to the greatest good of all our people.

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THE USE OF FIRE IN THE PROTECTION OF LONGLEAF AND SLASH PINE FORESTS

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The Occasional Papers of the Southern Forest Experiment Station present information on current southern forestry problems under investigation at the Station. In some cases, these contributions were first presented as addresses to a limited group of people, and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

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THE USE OF FIRE IN THE PROTECTION OF LONGLEAF AND SLASH PINE FORESTS

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The southern Coastal Plain during the late winter and early spring of 1943 suffered one of the worst fire seasons in the experience of organized forest fire protection in this region; losses in the first 4 months of 1943 were approximately double the average annual loss for the past 8 years. Fire losses were particularly severe in the longleaf and slash pine portion of the Coastal Plain because of the long drought, large number of fires, and shortage of experienced labor for fire control.

Forest land owners and managers in the region of longleaf and slash pines are faced with a critical protection problem; recurrence of these severe conditions threatens the destruction of all or most of the growing stock on individual properties. In this situation, they are becoming increasingly interested in the use of fire as an aid to forest protection.

This use of fire has been developing slowly for several years; the very destructive fires of 1932 and 1934 led several forest managers in various parts of the longleaf pine belt to try winter burning to reduce hazardous fuel accumulations. Since then many properties have been so treated, first experimentally, then regularly, especially in south Georgia and northeast Florida where many leaders recognize this use of fire as a substantial aid to the successful management of slash and longleaf pine forests.

Misunderstanding and confusion obscure this practice, partly as a result of the term "controlled burning"—a loosely defined phrase which has widely divergent meanings to different people. Further confusion has been created by the criticism of those who, opposed to any use of fire in forestry, have strongly condemned it. Finally, the objectives, dangers, and full potentialities of this tool in forest management have not been clearly recognized by those using fire in forest protection, with the result that some burning has been either ineffective or definitely harmful.

This paper is prepared for the owners and managers of forest land on which the growth of forest products is the main objective. Its purpose is to present a preliminary guide for the improvement of current practice in the use of fire in forest protection. It is based on intensive studies of the behavior and effects of forest fires in these types, following several years of experimenting with the use of fire, and on the advice and experience of many operators and owners who are currently using fire in forest management.

FIRE PROTECTION

Woods burning in this region began with the Indians and was continued as a form of forest culture by the white civilization which followed. While timber was of little value, the forests were used principally for grazing and hunting; fire improved these forest uses. Woods burning is still practiced promiscuously, although now the value of the timber resources usually greatly exceeds other uses of the land. Fires here are so common that of the area burned over in the United States, about nine-tenths is ordinarily reported from the 11 Southeastern States.

Forest fires in the longleaf and slash pine forests have extremely high rates of spread, frequently burning 100-250 yards per minute in the direction of the wind. These high rates are explained by the openness of the stands, permitting high wind velocities near the ground, and by the erect, dense, herbaceous fuel, permitting flash combustion. Fires are frequently large before suppression can be started.

Both longleaf and slash pine, the important trees of this region, are fire resistant. The remarkable ability of longleaf pine to survive and grow in spite of repeated burning accounts for the formerly extensive virgin forests of this species. In the first year longleaf seedlings are easily killed, but the buds of older seedlings are protected by plumes of resistant needles, and the vital cambium of older trees is protected by a thick bark of low conductivit Slash pine, although readily killed by light fires as a small seedling, is much more fire resistant than was formerly supposed. It soon develops a thick bark and from the sapling size onward approaches longleaf pine in its resistance to fire.

In southern Georgia and northeastern Florida freedom from fire for a few years usually results in dense stands of thrifty slash pine reproduction along swamp margins and in other localities where seed supply is abundant. Longleaf pine reproduces less successfully because of infrequent seed years, damage by hogs, and delayed height growth; where both are found in association, slash pine is now usually ascendant.

With the extension of young slash pine, the difficulties of forest protection increase. The high grass rough[1] remains while undergrowth increases and needle litter accumulates. Wildfires become more difficult to control, and a rising threat to the valuable reproducing stands. This trend continues indefinitely in such stands, leveling off only after about 20 years of fire exclusion.

In the northern and western parts of this forest region, slash pine is scarce or absent. Here the original longleaf pine forest has in many places been succeeded by shortleaf and loblolly pines and hardwoods during the past 50 years. This latter type has a litter fuel which, together with a lowered wind movement resulting from the denser stands, greatly simplifies forest fire protection. There is little or no evidence supporting the use of fire in protecting this forest type.

Over much of the region, however, main dependence for future stands must rest on longleaf pine. With this species freedom from fire is necessary in the year following seedfall, while wildfires of ordinary intensity are undesirable in all reproduction. Long periods of fire exclusion, however, have been found hazardous in growing longleaf pine. Fuels accumulate steadily for 20 years or more in fully stocked stands. Fires during the latter part of this period may completely destroy thrifty second-growth stands as at Urania, La., in 1932.[2]

1/ Rough: An accumulation of all living and dead herbaceous vegetation, especiall grasses, and forest litter sometimes with the addition of underbrush, such as palmetto, gallberry, and waxmyrtle. The term is most often used to designate the ground cover of longleaf and slash pine forests when unburned for 1 or more years.

2/ Bickford, C. A., and Henry Bull. A destructive forest fire and some of its implications. Southern Forest Experiment Station, Occasional Paper 46, 4 pp. Apr. 15, 1935.

On lands reproduced to longleaf pine, periodic burning to reduce fuel accumulations and to control brown-spot has been widely recommended and occasionally used. The high fire tolerance of this species makes such use of fire neither difficult, costly, nor hazardous.

USE OF FIRE

Forest managers in the Southeast attempt to exclude fire completely until slash pine attains a height of 5 or more feet. From this point, practice varies; some continue a fire exclusion policy; others, in the fear of extreme losses arising from the associated accumulations of fuel, are burning under conditions selected to minimize damage to these young stands.

Farther west and north in the longleaf-slash region, where slash pine is less common, owners of forest land have used fire less frequently. The more open stands are less likely to produce dangerous fuel accumulations and use of fire there is more silvicultural than to assist in or to simplify forest protection.

The development of fire as a tool in forest management has come about gradually. First was the realization by some forest owners and managers that certain fires, or parts of fires, resulted in little or no damage to the forest. This was followed by the recognition that fire of the less injurious variety might be good forest management if confined to appropriate areas. Next came the definition of several valid uses of fire in forest management: seedbed preparation, control of the brown-spot needle disease, undergrowth reduction, and reduction of accumulated fuels to aid fire protection and to insure young fire-sensitive stands. Finally, R. M. Conarro[3/] pointed out that each use of fire has one dominating motive and that appropriate burning specifications may vary widely, depending upon this motive. Following this reasoning, Conarro developed the concept of "prescribed burning" where fire is used only for certain recognized purposes and on lands where these uses are valid. As the term implies, a unit where fire use seems suitable is studied carefully to determine the appropriate fire treatment needed to meet the dominant motive. This study, or diagnosis, is followed by the "prescription" which specifies where, when, and how to burn to accomplish the objective.

The proper use of fire is thus seen to consist of three steps: analysis, planning, and execution. The analysis defines the purpose and weighs advantages against disadvantages; where anticipated costs and losses are greater than probable benefits, fire should not be used. The plan defines the area to burn and the time and manner of burning needed to fulfill the purpose with as little injury as possible to the stand. And, finally, the area is burned, following the plan as closely as circumstances permit.

A discussion of both the obstacles and the advantages of fire use follows, with a suggested form of analysis to arrive at a sound conclusion on the use of fire.

Obstacles

The major obstacles to fire use are: damage to timber resources, expense of burning, mixture of sizes in present stands, and possibly unfavorable public reaction. Damage includes the killing of smaller trees, reduced growth, creation or enlargement of bole injuries, and impairment of the soil; some damage in one or more of these forms is an inescapable part of using fire extensively.

3/ Conarro, Raymond M. The place of fire in southern forestry. Jour. Forestry 40 (2): 129-131. Feb. 1942.

Fires of low intensity kill virtually all longleaf pine seedlings during their first growing season and many slash pine less than 5 feet in height. Fires of moderate intensity kill numerous slash pine 5-20 feet in height and longleaf pine ½-5 feet in height, especially when attacked by brown-spot. Larger pines usually survive all but the most severe fires.

Such fires often kill all the needles and actually consume a portion of them by spot crowning; where this occurs, buds are killed too and the tree dies in many cases. This mortality is an important aspect of the damage caused by severe fires. Badly scorched trees, especially in late spring, summer, and early fall fires, are frequently attacked by Ips beetles. Epidemic infestations following severe fires may result in complete killing of entire stands.

In prescribed burning, losses in growth resulting from defoliation of the trees by the heat of the surface fire may be important. Loss of one-third or less of the foliage of these pines normally results in no measurable loss of growth. Complete browning of the needles, on the other hand, commonly results in losses equivalent to about 1 year's normal growth—this loss being distributed over about 3 years with 6/10 in the first, 3/10 in the second, and 1/10 in the third year following the fire. Losses in growth from intermediate degrees of heat defoliation are roughly proportional to the degree of defoliation.

Although fire alone rarely creates scars on these pines, on a wounded tree it may produce important damage by enlarging and extending the injury. This is particularly evident in burned turpentined woods where fire accelerates the destruction of worked-out trees by progressively weakening the lower boles until they become windfalls. The turpentine borer is especially destructive when the protective coating of hardened resin is burned from a face.

Stands that have been utilized for naval stores may suffer important damage from use of fire. Good forest management requires reasonably continuous working until utilization is complete, and the prompt removal of worked-out trees. It is common, however, to find trees with both working and worked-out faces throughout timber stands in the naval stores belt. Fire use in such stands is expensive because of the injury to these faces if not raked carefully and because of the high costs of raking. Damage in such stands may include breakage at the face, degrade, reduced volume, and, on trees being worked, lowered quality and quantity of gum production and destruction of cups and gutters.

Practices in preparing such stands for prescribed burning vary and definite recommendations to cover all cases cannot be made. All working faces are customarily raked before burning. Resting unburned faces are usually raked also, and this is considered good practice. Worked-out unburned timber will be weakened and will suffer considerable degrade in burning and may often be profitably raked especially where the timber is to remain standing for several years. Burned worked-out timber will ordinarily not be raked. In treating a turpentined stand the various losses which may occur in burning should be weighed against the advantages of burning and the costs of raking to determine the most economic stand treatment.

The influence of burning on the soil has been studied by Heyward and Barnette[4/] and others. This work has shown a small improvement in the chemical properties of the soil as a result of burning, while the physical properties have

4/ Heyward, Frank, and R. M. Barnette. Effect of frequent fires on chemical composition of forest soils in the longleaf pine region. Fla. Agr. Expt. Sta. Tech. Bull. 265, 39 pp., illus. Mar. 1934.

been slightly impaired. In general, the research on this subject gives no strong reasons either for or against the use of fire; further work may detect other damages that are now obscure.

Accidents, failures, and errors in burning operations are the principal sources of damage. Injury is usually present wherever fire is used but the most damage occurs on areas that were burned more severely than was intended for various reasons, such as changes in wind direction or through failure to prepare a strategic line, or mistakes in setting the fire. The most common damage results from wind variations over which the burner has no control.

The importance of wind in using fire can hardly be overemphasized. A shift in direction of more than 90° converts a backfire into a headfire; a lull, when burning in young stands, may increase defoliation tenfold because the heat, which was being largely dissipated, rises vertically to scorch the crowns of the young trees, perhaps killing them. Accurate weather forecasts are seldom available and the burner, unable to control wind, must cultivate an ability to predict its behavior.

Costs are an important drawback to the use of prescribed burning in this region. Costs per acre decrease as the size of area and the age of the stand increase; increase as the age of the rough, stand density, increase. Shape of the area has an important bearing on costs, as have the amount of line preparation and the size of the crew. Where flank fire and occasional head fire can be used, burning will be much more rapid and less expensive than where back fire alone must be used. Weather conditions influence the spread of fire and consequently strongly affect cost. The presence of gallberry and palmetto increases difficulty of burning, and costs. Where there is little possibility of damage, burning can be done at very low costs. Where such damage may be appreciable and would be reduced by thoughtful planning and careful execution, such inexpensive burning may be poor management.

Stands vary widely in the damage possible under prescribed burning, and the justifiable costs in controlled burning vary through a similar range. Costs of as little as 1 cent an acre are possible under some conditions, while costs of 30 cents or more for areas of heavy rough and mixed sizes and conditions may occasionally be most economical.

The success of prescribed burning depends to a large extent on the development of economic techniques for accomplishing the desired objectives. Careful planning and the choosing of appropriate weather conditions for the burning should be relied upon rather than large crews to accomplish difficult burning chances.

Frequently, use of fire in forest protection, if planned with that end in view, will result, through the establishment of barriers, in a large measure of protection for an entire forest unit. In such cases, the cost of the operation is a proper charge against the whole unit and may amount to a small fraction of a cent per acre for the whole area. In any event, the cost per acre protected is a more significant figure than the cost per acre burned.

The mixed and patchy character of most stands is an important impediment to using fire, especially where slash pine is common. Theoretically it is only necessary to select areas that are easy to burn and proceed with the job; practically these areas are hard to find because of the boundless mixing of ages, sizes, turpentine faces, and species, sometimes in the same stand, sometimes separately by very small areas, and, only occasionally, separately by areas sufficiently

large to burn efficiently. This mixture of tree ages and sizes complicates an already difficult problem; in time, it may be simplified by following the principles of even-aged management. For the present, the exercise of careful, thoughtful judgment is imperative in choosing the areas on which fire may be used. This judgment should be guided by appraisals of probable effects of fire.

The least tangible disadvantage to using fire is the influence of such use on public opinion. It is a direct contradiction of much of the fire prevention propaganda that has been broadcast. For foresters to now make use of fire appears, to many who have actively worked on these campaigns, a distinct breach of faith and a reversion of policy which may result in discouragement and confusion. There is the danger too that use of fire by foresters may stimulate and extend the already promiscuous woods burning.

Use of fire in forest management may have a favorable as well as an unfavorable influence on public opinion. Many southerners who have long seen an advantage in fire use will be encouraged by the general recognition of this tool. Promiscuous fires may be reduced, at least to the extent to which prescribed burning meets the objectives of the promiscuous burner. Forest practice will be encouraged by the development of a practice which largely removes the possibility of large damaging fires.

Public reaction to the use of fire is at present unpredictable. Fear of unfavorable public reaction exists and is one of the strong deterrents to the use of fire in forestry.

Benefits

The benefits of using fire in forest management can be placed in two classes: those which facilitate forest protection and those which improve forest production and forest values. Protection is made easier by the reduction or temporary elimination of accumulated fuel resulting in a temporary elimination of wildfires and a lowering of their intensity over a longer period.

Burning for fire protection has its chief impetus in the desire of the forest land owner to escape from the catastrophe of complete forest destruction. At infrequent intervals and at various places throughout this belt a period of successful forest protection has been followed by a few large fires of extremely high intensity and destructiveness. The occurrences have sometimes resulted in the destruction of entire operations, and have been a serious drawback to the extension of private forest management. To the landowner controlling 20,000 acres or less in a block such fires are particularly threatening, for his whole investment might be wiped out in a single day. A program which minimizes the occurrence of such disasters should encourage the individual landowner, and, through him, result in the increase of forest management.

The most common benefit sought is the reduction of damage in young stands. Well-stocked stands of young slash pine are common in the Southeast on areas unburned for several years. Fuels accumulate rapidly in such stands to the point where fires crown under most burning conditions. Where the crop trees are 10 feet or more in height and not too dense, such a stand can be treated, under appropriate conditions, with insignificant losses to the growing stock. Burning under these conditions has an extremely high insurance value since, by the time the fuel reaccumulates, the stand will be much more fire resistant.

In denser stands in the Southeast the successful use of fire is often difficult and, as such stands offer profitable thinning chances, thinning and burning have often been combined, with burning following the thinning by a few days. The openness of the thinned stand permits the wind to dissipate the heat more effectively while the green debris from the burning reduces fire intensity. Some operators prefer to defer burning following thinning for a period of several months to a year to permit the partial decay of the debris.

The accumulation of fuels in older stands of these types is also a serious threat to their safety and development. Under the worst fuel and weather conditions, fire may kill the largest and most fire-resistant pines. Any wildfire in such fuels is likely to be highly injurious to the stand and especially to that portion exposed to the head fire. Burning to reduce the accumulated fuel provides a few months of absolute protection, and several years of progressively diminishing insurance from excessive damage. Removal of fuel accumulations results also in easier fire suppression which in turn should result in substantial savings in area burned and in damage. The normal build-up of fuels following a burn proceeds rapidly at first and then levels off at about 3 years in open stands where the fuel is mainly herbaceous to about 20 years in dense stands where the needle cast and other forest litter are important.

Burning to create barriers to fire spread and strips of thin fuel that permit direct attack on fires is a potentially valuable use which has been only partially explored. Most fire damage, under organized protection, comes from a few fires starting under unusually favorable burning conditions and spreading rapidly over thousands of acres before their spread is stopped. The burning of 5 to 10 percent of an area, in strategically located strips, can be of great value in reducing the size of such fires. These barriers or protective strips should usually be about 200-300 yards wide, continuous, and properly located with reference to critical winds; there should be some burning each year, but burning the same area in two successive years should be avoided. Such strips should result not only in reducing the size of the largest fires, and damage in proportion, but should also reduce the costs of fire suppression.

Burning to reduce accumulated fuel and to create barriers may also result in a small reduction in the number of wildfires. Fires due to carelessness should decrease about in proportion to the area burned. Wilfully set fires may be reduced to the extent to which the area treated also meets the objectives of the woods burner. Ordinarily, these motives will not be completely satisfied and fires from this source will continue.

The use of fire does not eliminate the need for an effective organization for fire control. By limiting the size of fires and reducing the difficulties of control, however, prescribed burning should theoretically reduce the fire control forces required in comparison with those needed when no use is made of fire. Practically, there may be no immediate reduction in protection costs, because of the present inadequacy of most fire control efforts.

Besides fire protection, there are several possible benefits to the use of fire in these types. Most such benefits apply, however, to limited areas and for short periods only. The most important benefits are in silviculture, grazing, game management, and in the use of fire to improve utilization. In general, using fire for one of these other purposes demands a special plan and justification. Frequently, however, fire used for protection will also provide certain silvicultural or other advantages which should be duly considered in analyzing the desirability of this practice.

The main silvicultural benefits from burning are improved seedbed, disease control, and reduction of weed species. Pine seeds germinate in greater numbers[5] and develop more rapidly when they fall in fresh burns; this advantage is small with slash pine but important in the regeneration of longleaf pine. Planting costs may frequently be decreased through burning. The brown-spot needle disease in stands of longleaf pine seedlings in the grass stage may be lowered by destruction of the infected foliage by fire. Burning to thin thickets of young slash pine has been suggested, but is not recommended because of the tendency of fires to kill trees in groups and because the trees killed by fire are commonly better crop trees than those left.

Control of weed species is important in the management of longleaf and slash pine forests, and fire used properly can be an effective agent in such control. The most important weeds are the various scrub oaks, but other woody shrubs and hardwood trees also tend to increase with prolonged fire exclusion. Fire alone will not halt the invasion of hardwoods, but repeated fire with shade of a pine overstory can be used to eliminate these species. Repeated burning for this purpose may result in some loss to the pine stand and should be used only after full analysis of both the advantages and disadvantages. The use of fire to control hardwood invasion is a complex subject; much remains unknown, but evidence supporting this use is promising.

Undergrowth frequently impedes utilization of the forest. Naval stores operators prefer burned woods because of the lowered costs of cupping, chipping, and dipping, and particularly because of the lessened risk of loss of gum, cups, and faces through wildfire. Turpentine workers have a strong aversion to snakes and prefer to work in burned woods which afford less cover for these reptiles. The harvesting of other forest products is also impeded by a dense ground cover and undergrowth. The partial cutting of pulpwood in rough woods, for instance, is often unattractive to contractors because of the difficulties of bucking, finding, and loading bolts.

Profits from livestock production as ordinarily practiced in this region are usually too small to attract the investment of private capital in unimproved land for this purpose. Grazing is, nevertheless, a locally important industry and burning of the range to improve forage for cattle and sheep is a recognized practice with established benefits. In tracts managed for forest products, grazing is often permitted or tolerated and may provide a significant part of the forest income. Forage plants in the pine types are progressively reduced by fuller stocking of trees and by fire exclusion; the effect of needle cast in smothering grasses is marked in dense stands. Periodic light fires commonly prolong the grazing resource on such areas. Plants growing on early spring burns are highly palatable over a short period; cattle herd on such areas and do well on the forage. Cattle owners prefer regular spacing of small burns every few weeks to the burning of an equal or larger area at one time. Burned areas are used to gather stock for such purposes as branding and shearing.

Fire, properly used, has also been found valuable in the management of wild land for quail and turkey.[6] These and other game may be benefited by the appropriate use of fire as developed by specialists in this field.

5/ A noteworthy exception results from the occasional concentration of seed-eating birds on fresh burns.

6/ Stoddard, Herbert L. The bobwhite quail. 505 pp., illus. New York. 1931.

ANALYSIS

A careful analysis in which the dominating motive is clearly defined and the expected costs and damages are weighed against the anticipated benefits should precede each use of fire. Such analyses focus attention on important elements, clarify the issue, and should prevent burning those areas where the disadvantages exceed the advantages.

Variations in fuel and stand conditions, in objectives of management, in fire occurrence and size, and in other factors make it desirable to appraise each forest unit separately in determining the desirability of using fire. Each element of cost, damage, and benefit should be estimated as accurately as possible and totaled, subtracting the expenses from the gains. Where the net result is negative, use of fire is improper and no further effort is needed. Where it is positive, however, there is a valid use of fire and the forest manager should proceed with the planning and burning.

In such an analysis three steps are recognized: (1) recognition of the purpose of the burn; (2) general comparison of advantages and disadvantages for the whole area influenced; and (3) specific analyses of proposed burning units.

The advantages and disadvantages of using fire have been previously discussed. To make the analysis, it is necessary to evaluate each for a specific property. Public reaction to the use of fire is an intangible impossible to evaluate, but it should be weighed against any positive net advantage resulting from an appraisal. Where the net advantage is small, unfavorable local reaction may veto the use of fire.

Another intangible is the risk of fire of unusually large proportions such as the Cogdell (Ga.) fire of 1934; similar large fires have occurred on the Osceola National Forest (Fla.) in 1932, 1941, and 1943. Such fires may spread over several thousands of acres in a few hours, wrecking the forest operation. The risk of such a fire on a particular property is difficult to evaluate, yet such risk is an important consideration in most instances of fire use.

The following assumed data illustrate a simple analysis:

Present situation:

Area protected	50,000 acres
Period of protection	10 years
Annual protection cost	$5,000
Mean annual loss	3,000 acres
Mean annual damage	$4,500
Fires over 1,000 acres in 10 years:	
Number	12
Total area burned	23,000 acres

Analysis of use of fire:

Purpose: reduction of damage from wildfires.

Area to burn: 5,000 acres.

Estimated costs (for 1 year):

Ordinary damage from using fire	$ 200
Extraordinary damage due to accidents, mistakes, etc.	600
Costs of burning	1,000
Subtotal	$1,800

Estimated benefits (for 1 year):

Reduction in damage from wildfires	$2,000
Reduction in suppression costs	300
Other benefits	250
Total	$2,550

The above analysis shows a net advantage of $750 for the use of fire. The analysis is not complete, however, without weighing two intangibles, one an advantage, the other an obstacle. Fire use decreases to a marked degree the possibility of a fire of large size and high intensity on the area treated. On the other hand, use of fire may have an unfavorable public reaction, resulting in more fires and more damage. Unguided judgment must be relied upon at present in evaluating these important factors. One or the other of these intangibles will frequently be the deciding influence in arriving at a local policy.

Such analyses can never provide complete and positive answers to the wisdom of the practice. They provide, however, for proper consideration of each important factor and are the proper basis for decision.

PLANNING

Where the analysis has established the desirability of using fire, the next step is planning the burn to accomplish the dominant objectives with a minimum of injury to the stand. The plan should specify the exact area, the most appropriate time, and the most efficient manner of burning, considering the particular requirements of the stands and the attendant costs.

Area To Be Burned, and Pattern

Early in planning, a decision should be made on the amount of area to be burned and its location. Decision on these points must be governed mainly by such local considerations as distribution of age classes, amount of labor available, and previous occurrence of fires, but there are a few principles of general application which should be considered in all planning.

The size of the area to be treated by fire in any one year is frequently confined by such practical considerations as the amount of manpower and equipment available and by the length of the burning season. Those who use fire in forest management frequently fail to treat the area planned because of unfavorable weather conditions or scarcity of labor, or both. It is unwise, however, to plan on too extensive treatment in any single year. One reason is the desirability of continuous fire use, while the cost involved in treating a large proportion of the area in a single year is another. The area treated in a single year should rarely exceed 15 percent while burning as little as 7 or 8 percent of the area may prove most efficient. An exception might be made in the first years of using fire after a long period of fire exclusion when extraordinary measures might be adopted to reduce all heavy fuel accumulations within a period of 3-5 years. A rotation of fire treatment of 7-18 years should, however, prove most efficient after this initial period of fuel reduction.

Distribution of burned areas is important because of the influence which recently treated areas have on fire spread and on fire suppression. Most burning for fire protection to date has had for its primary purpose fuel reduction to provide insurance against destructive wildfires. Burning operations for this purpose alone are frequently justified, but an obvious advantage exists in burning so as to form more or less continuous strips, thus blocking the unit into areas surrounded by wide fire barriers[7] effective for several months after the burning operations. Planning burning operations so as to make such barriers is strongly recommended.

7/ In this paper, "barrier" has been used to describe wide strips of freshly burned areas, while "break" has been used for narrower strips (e.g., plowed lines, roads, small streams, etc.).

Barriers to be effective should be wide enough to stop the head of severe fires. Necessary widths under bad fire weather are unknown, but a width of from 8 to 10 chains is probably the minimum which should be considered for these types. For a given area treated, the wider the strips, the fewer will be possible, so strips of the minimum width necessary to stop severe conflagrations are desirable. A strip 8 to 10 chains wide can ordinarily be burned out easily under control in a single work period and may be a convenient width if found to be sufficiently wide to serve as barriers.

Barriers to be reliable should be reasonably continuous. Continuity in burning is made difficult by the presence of swamps and ponds which cannot be treated and by the presence of reproducing areas below the age and size of safe burning. To overcome these difficulties, strips can frequently be meandered around such obstructions. In addition, strips may be widened into zones in districts where patchy reproduction occurs, with the burning confined to the older age classes.

Location of barriers in relation to the prevailing wind directions during the fire season is important. It is recognized that a barrier is most effective against a fire burning to it at an acute rather than at a large angle. If a wind direction common to bad fire days can be recognized, barriers should be planned to run at an angle of 60° or less to such direction.

Pattern of burning will frequently be influenced by large areas in the reproducing sizes, and by many other local considerations such as areas of heavy fire occurrence. The first step in planning, however, should be to lay out on a map of the unit a desirable distribution of areas to be burned, using only the general information on stand conditions available to the forest manager. With this general plan, the selection of definite areas or units for burning can be undertaken by field examination. A general pattern of burning is shown in figure 1.

Selection of Burning Units

The next step in planning is the preliminary adjustment of the pattern to fit conditions in the woods, locating burning areas to minimize injury while preserving the general scheme. To do this efficiently, it is necessary to classify the area on fuel and stand conditions and to set up burning units that fill out the design.

The following classification is recommended: (1) unburnable areas (ponds, lakes, and other areas on which fire will not spread); (2) areas which must not be burned because of stand conditions; (3) areas difficult or expensive to burn; and (4) areas easy and inexpensive to burn. Areas difficult and expensive to burn are often those in greatest need of treatment and should not be omitted or deferred on the basis of difficulty and expense alone. The main elements which define these classes are: the fuel, its composition, arrangement, and amount, stand density, and the species and size of crop trees. Table 1 has been prepared as a guide to stand classification.

Fig. 1. Proposed pattern of burning for 13,000-acre block in the Louisiana Coastal Plain (after preliminary survey).

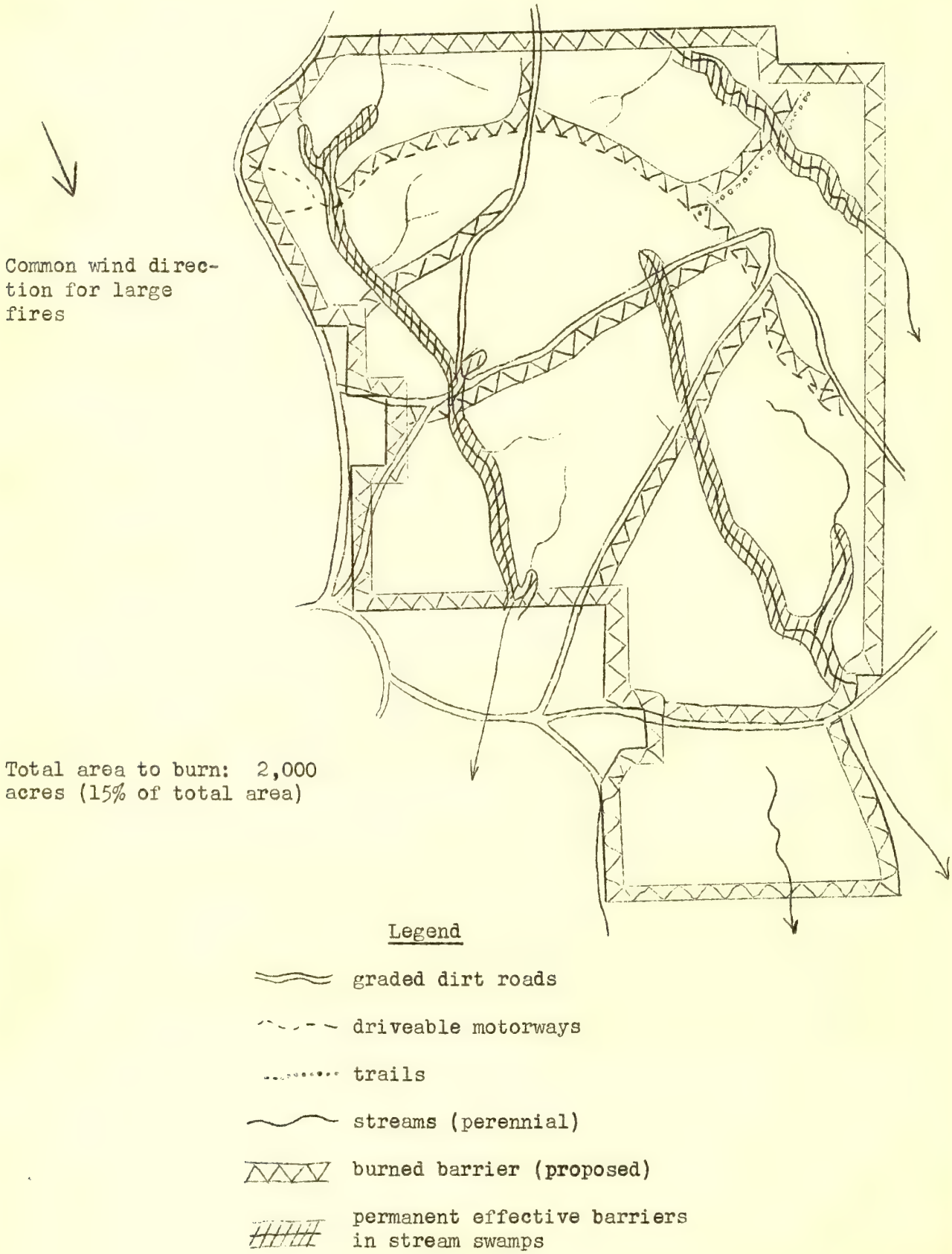


Table 1. - Fuel and stand classes for using fire.

Species of crop tree	Fuel	Pine density	Palmetto	Crop trees							
				Age	Size (age 2 or more) Height						d.b.h.
				Less than 1	0'-1'	1'-5'	5'-10'	10'-15'	15'-20'	20'-4"	4"+
				Fuel and stand classes[c]							
Longleaf pine	Draped litter fuel[a]	Open	Present	0	0	0	0	0	0	0	0
			Absent	0	0	0	0	0	0	0	0
		Dense	Present	0	0	2	2	2	2	3	3
			Absent	0	0	0	2	2	2	3	3
	Undraped litter fuel[b]	Open	Present	1	0	0	0	0	0	3	3
			Absent	1	0	0	0	0	0	3	3
		Dense	Present	1	0	0	2	3	3	3	3
			Absent	1	0	2	2	3	3	3	3
	Grassy fuel	Open	Present	1	3	2	2	3	3	3	3
			Absent	1	3	2	2	3	3	3	3
		Dense	Present	1	3	2	2	2	3	3	3
			Absent	1	3	2	2	3	3	3	3
Slash pine	Draped litter fuel	Open	Present	1	1	1	1	2	2	2	3
			Absent	1	1	1	1	2	2	2	3
		Dense	Present	1	1	1	1	1	2	2	2
			Absent	1	1	1	1	1	2	2	3
	Undraped litter fuel	Open	Present	1	1	1	1	2	2	2	3
			Absent	1	1	1	2	2	2	3	3
		Dense	Present	1	1	1	1	2	2	2	3
			Absent	1	1	1	1	2	2	3	3
	Grassy fuel	Open	Present	1	1	1	1	2	2	2	3
			Absent	1	1	1	2	2	2	3	3
		Dense	Present	1	1	1	1	2	2	2	3
			Absent	1	1	1	2	2	2	2	3

a/ Draped litter fuel: Needles of pine conspicuously present on shrubs and lower limbs, frequently in such amounts as to partially smother low shrubs.

b/ Undraped litter fuel: Needles confined principally to bed on the ground.

c/ Fuel and stand classes: 0 - ordinarily does not occur. 1 - do not use fire. 2 - difficult or expensive to burn properly. 3 - easy and inexpensive to burn properly. The presence of 10 or more unburned turpentine faces per acre makes an area, otherwise easy and inexpensive, difficult or expensive to burn.

A burning unit is an area of such size and shape that, considering its fuel, stand, and burning conditions, one crew can burn it properly in one work period (8-12 hours). These units will vary in size over a wide range depending on fuel and stand conditions, reasons for burning, objectives of management, and size of crew. Each such unit should be surrounded by adequate firebreaks (i.e., plowed lines, streams, swamps, or other obstacles to spread) and should be burnable with a reasonably uniform fire intensity.

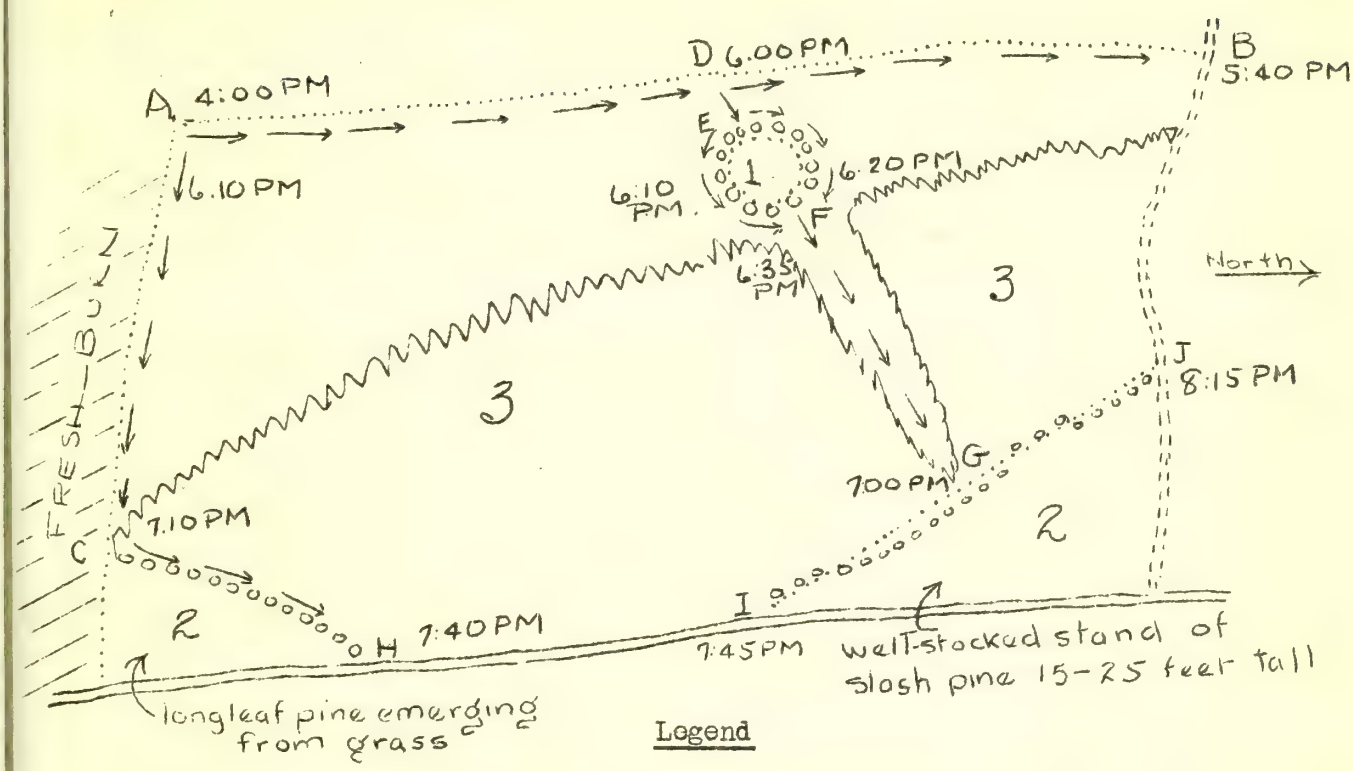
A preliminary examination which selects the area to burn and tentatively subdivides it into burning units is recommended. The primary considerations in selection are the over-all pattern, continuity of the network, ease of burning, and anticipated benefits. Usually, islands or blocks where proper use of fire would have a high insurance value should be selected first and subsequently connected by strips through areas that are easy to burn. As the examination proceeds, approximate burning unit boundaries should be sketched on the map. Size of burning units will vary widely but about 10 acres is the minimum.

After the area to burn has been selected, a detailed sketch map and description of each burning unit, showing boundaries, location of firebreaks, special problems of burning or protection, and classes of area should be made. Revision of the burning unit boundaries may often be necessary to increase uniformity or to provide a more efficient work unit. The mapper should imagine that he is burning each unit examined and attempt to solve the problems of the burning crew. Uniformity of fuel and stand throughout a burning unit is desirable, but the patchy, uneven condition of present stands often makes this difficult or impossible. Major irregularities within burning units must be recognized and mapped for the guidance of the burning crew. Marking the outside boundaries to guide the burning crew after dark has been found desirable by at least one operator.

The sketch map is the final record of this examination. This map should show size and shape of the unit, location of all firebreaks, detailed fuel and stand classes—in short, all the information needed for planning the burn and managing the fire. Excessive detail should be avoided, but all usable information should be shown. For general guidance, 1 acre is recommended as the smallest practicable unit in mapping stand variations.

A burning plan is prepared for each unit from the sketch maps. These plans should be positive, simple, clear, and brief. A sketch map on a single letter-size sheet with instructions below is a desirable form for these plans. The instructions should specify: (1) additional firebreaks needed, exterior and interior; (2) size of crew and duties of each member; (3) equipment and tools necessary; (4) season and time of day to start the burning; (5) wind directions under which to start the burning; (6) other important weather elements; (7) point or points at which to start the burning; (8) direction and rate of spreading fire; (9) provisions to meet changed burning conditions. Figure 2 illustrates a plan for a burning unit. These are suggestions to the crew leader to guide him in his burning; he must also use judgment to revise this plan to meet conditions actually encountered.

Fig. 2. A burning unit map and plan for southeastern flatwoods.



Legend

graded dirt road
woods road
lines to prepare before burning
fuel-stand class boundaries
direction, timing, and position of spreading estimated position of fire at 7 p.m. when straw boss has reached point G.

Fuel-stand classes:
1-burning undesirable
2-burning difficult
3-burning easy

BURN ON NE WIND

Instructions

Start at A, 2 hours before sunset, and spread fire northward 50 chains to B, 1 man spreading, 2 men patrolling. One man stays at B to advance along woods road with fire. One man returns to A, spreads fire 15 chains to C, then burns area of young longleaf with a backfire after dark. Third man (straw boss) returns to D, spreads fire NE to E, thence to F, first north then south of small slash pine, then NE from F to G. Straw boss joins man at C, with him spreads fire to H, extinguishing westerly flank. Straw boss returns to I, spreads fire to J to burn out area of 15'-25' slash pine, then replaces man left at B who mops up as needed from B to A. Unit burns out about midnight.

Timing of Operations

Season of the year, time of day, and weather conditions are all-important in the effective use of fire. During the winter season the pines become dormant and less liable to damage; at the same time the herbaceous fuels die and cure. For most purposes, burning during the dormant winter season is desirable because of the lessened liability of injury to the pines and also because the cured herbaceous fuel permits burning over a wide range of moisture conditions (up to about 65 percent oven-dry weight). Occasionally, as in seedbed preparation, fire will be used at other periods. These cases are, however, exceptional and should generally be avoided because of the greater activity of barkbeetles. The most appropriate season in the lower Coastal Plain extends from about November 15 to March 15. Where practicable, burning should be confined to the period December 15 to February 28.

Time of day is important in planning burning operations because of the associated variations in fuel moisture and wind behavior. At sunrise, in clear winter weather, the fuel is ordinarily saturated and the wind very low. The wind rises as the day advances and the fuel becomes progressively drier. Shifting, gusty winds during the middle of the day are common as a result of unequal heating of the earth's surface. As sunset approaches, wind conditions become more stable and the moisture of the fuel increases slowly. At about sunset a lull in wind velocity is common; the wind ordinarily picks up after the lull and is steady in direction and velocity, gradually losing strength as sunrise approaches. Near the coast, wind direction often changes about sunrise and about sunset as a result of unequal heating of land and water.

Although fire can frequently be used throughout the daylight hours, conditions are most favorable from an hour or two before sunset until 3 to 4 hours before sunrise. Backfires should ordinarily be completed by dark, to gain advantage of the better visibility. Burning during the night can often be speeded by the wise use of flank fires, a practice discussed in the next section.

In general, moderate wind velocities of 5-10 miles per hour are preferable to lower velocities or a calm or to an excessively high wind. The major advantage of a moderately high velocity is its constancy, such winds having less variation in both direction and velocity. An added advantage is that higher winds on a backing fire dissipate the heat evolved more quickly, thus preventing the rising of hot blasts of air to defoliate the trees immediately above the flames. Steady winds of relatively high velocities are especially desirable in treating difficult areas, such as young dense stands of slash pine where damage under light and variable winds may be extensive. Excessively high wind velocities should also be avoided because of the danger of the fire escaping.

Throughout this region northerly winds are most stable, both in direction and in velocity, and are to be preferred in difficult operations. A recurring cycle of weather conditions is discernible throughout the Coastal Plain during these winter months. Warm cloudy days with variable southerly winds, frequently accompanied by rain, are followed by a period in which clear skies, cold nights, and steadier northerly winds are in prospect for about 3 days. This period of northerly winds is the preferred time for using fire on a hard chance. While burning under steady northerly winds is preferred, successful work can ordinarily be accomplished at other periods. Burning under other wind directions or with light and variable winds is definitely more risky and should be confined to small, less difficult burning units.

The limited number of days available for burning during the dormant season should be recognized in planning. Experience has shown that 3 or 4 days a week are ordinarily suitable for such work, Sundays excluded. Burning is usually possible from an hour or two after a rain until it rains again. Weather records for Florida and Louisiana over the past 50 years show that, on an average, there are 64 week-days suitable for this work in Florida and 52 days in Louisiana from mid-November to mid-March. In planning for any particular year, it would be conservative to discount these numbers to 55 and 45 days respectively.

Preparations for Burning

Preparations including maps and burning plans by units should be completed well in advance of the actual burning. It is usually desirable to plow lines around the boundaries of units, and to protect interior patches of small vulnerable pine. Existing breaks should be used as much as possible to keep the cost of this item small, but most use of fire will require some firebreak preparation.

In addition, one or more crews should be assembled and trained to carry out the work planned. Each crew should consist of 2-5 men under an experienced and qualified leader. All members of the crew should be thoroughly instructed in the purposes and objectives of the operation and in the part which each will play. Frequently it will be necessary to proceed slowly with the initial burning in order to train the crew members adequately in their respective jobs.

Adequate equipment should be assembled to provide not only for the actual burning operation but also for emergencies requiring fire suppression. Most of the actual firing will ordinarily be done by 1 or 2 men, but all should be equipped to spread fire. A rake with a long metal shank is an adequate backfiring tool; simple kerosene torches made from iron pipe have also been used effectively. Helpers will ordinarily be equipped mainly with flaps for stopping breakovers, but it is desirable to have other hand equipment available for emergencies. Below is a suggested list of such equipment for a 5-man crew:

Backfiring rakes	3-5
Torches	1-2
Flaps	5
Axes	2
Saws, crosscut	1
Backpack fire pumps	2
Shovels, round point	3
Fire rakes, Council or similar	1
Matches	

All equipment should be adequately housed and stowed on a pick-up truck.

Tractor-drawn plows and light pick-up trucks are desirable equipment on any burning job. The plowing of a certain amount of line is necessary to an effective job and either animal- or machine-drawn equipment may be used. Ordinarily plowing should be done ahead of the burning job; it is usually desirable to have preparations complete by about December 1. The use of plows should be restricted, because of the cost of operation, to the minimum amount necessary to provide adequate control on the burning units. Otherwise the costs of plowing may result in an expensive operation.

In addition to their use in preparation of units, the fireline plows provide a measure of insurance on burning operations. In case of breakovers or abrupt wind shifts, these units are a most effective method of controlling fires. Where available, plow units should be present on jobs to provide protection against such unexpected occurrences. A pick-up or other light truck equipped with power pump and water can also be used effectively in insuring against serious threats to the stand.

Weather governs fire behavior and wind is the most important single factor in the successful use of fire. Before starting to burn, therefore, weather conditions should be carefully studied in selecting the unit to burn. The limited forecasts available during the war period are of little value in planning; later, special arrangements for weather forecasts may be made. Current wind and rainfall records can frequently be maintained and consulted to improve the burning job. Experience with burning will gradually develop skill in anticipating changes in wind velocity and direction.

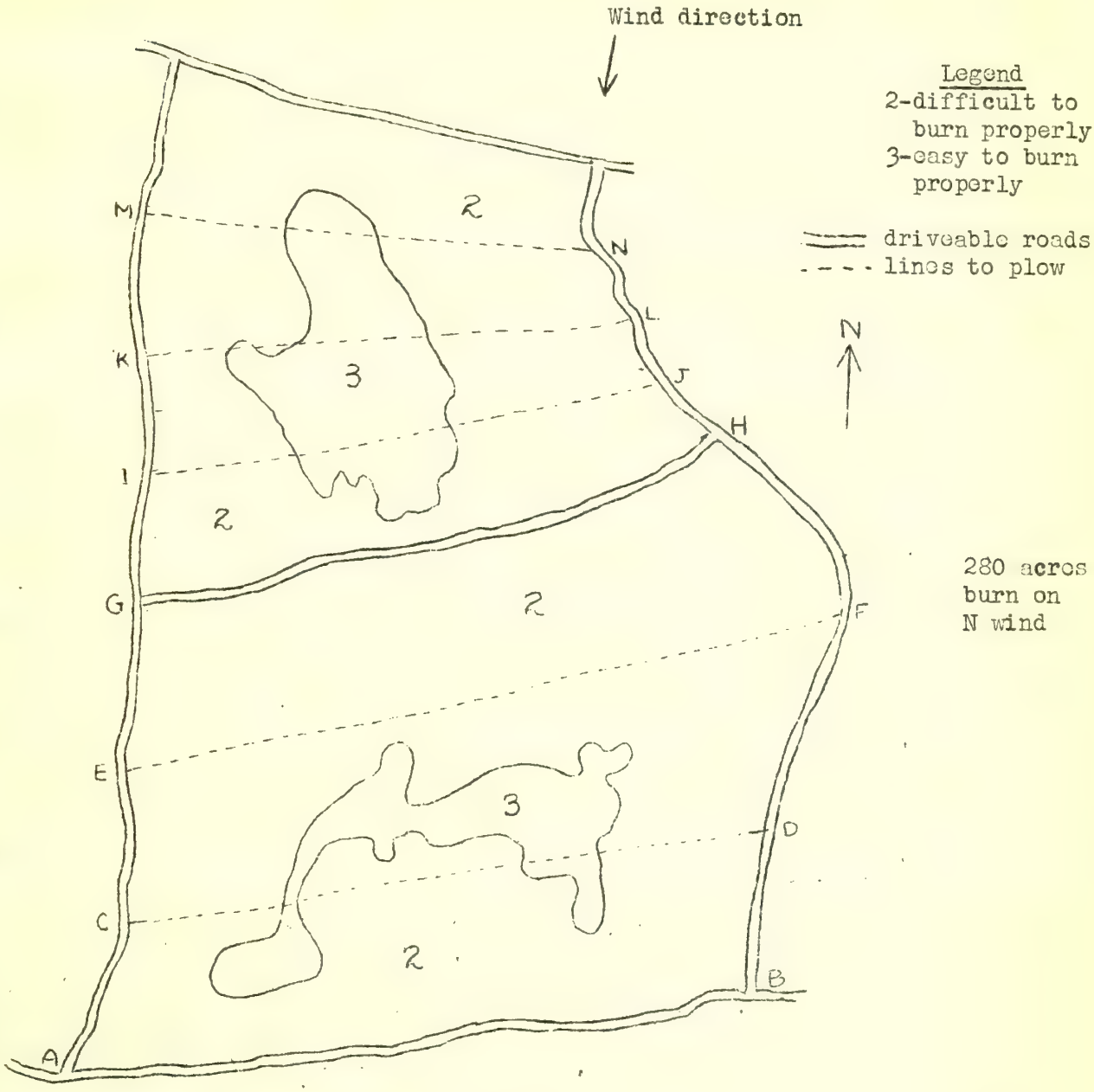
Burning Operations

With sufficient preparation, the job of burning should offer no particular difficulty to a trained and experienced crew. The first step is to establish a backfire along the leeward edge of the unit; the second is to extend the flanks to create a bow-shaped line of fire with the open end toward the wind. These two steps are usually followed by patrol and mop-up until the unit has burned over and is safe to leave. In an herbaceous fuel, backfires usually advance about a foot per minute; flank fires move appreciably faster, depending upon their angle with wind direction and upon wind velocity. Since there is ordinarily little difference in scorching, flank fires should be used to lower costs except where abundant fuel or fire-sensitive pine demands the lightest possible fire.

In burning units with a high length-to-width ratio, it is often desirable to spread lines of fire from the backfire into the wind across the unit to hasten the burning. Sometimes, particularly late at night, burning with the wind may be appropriate; costs are markedly reduced, but in most stands, the resultant injury vetoes its use. On units where only backfires are prescribed, plowed lines throughout the unit, thus permitting the use of two or more parallel lines of fire, perpendicular to the wind direction, will greatly expedite the job. Figure 3 illustrates burning a unit under this plan.

Mop-up and patrol are important here as on wildfires. Their proper use helps reduce the costs of burning and damage. Patrol begins as soon as the backfire is started and ends when all danger of escape has passed, but it need not be continuous. Mop-up should begin as soon as a man can be spared from establishing the backfire and should be concerned only with real threats to a breakover, snags and other sizeable burning objects close to the line. Once the back and flank fires are secure, continuous patrol is no longer needed. A morning check-up, however, starting 2-3 hours after sunrise, is a necessary part of safe practice.

Fig. 3. Illustration of simultaneous use of two or more parallel lines of backfire in burning unit under stand conditions requiring burning entirely against the wind.



Instructions

1. Plow lines: CD, EF, IJ, KL, and MN before burning.
2. Assemble 5-man crew at A at 4 p.m.
3. Leader explains plan to crew.
4. Spreading starts from A, C, and E at 5 p.m. with leader at A and 2 men at C and E, reaching B, D, and F at about 6 p.m.
5. One of men at D replaces leader at B and leader goes to G checking fire en route.
6. One of men at F goes to H and spreads fire toward G, meeting leader near G. 7 p.m.
7. Leader proceeds to I and spreads line IJ and is met by men left at B and D at 7:30 p.m.
8. Leader and 1 man spread lines KL and MN, complete at 8 p.m.
9. Crew mop up and patrol until 4 a.m. when fire is burned out.

Patience is the outstanding characteristic of the man who uses fire successfully. The job is slow and unspectacular. It involves long hours of waiting under some discomfort while a slow fire leisurely progresses across a unit. Without such patience, the foreman may, however, save time only at a considerable loss of young and valuable growing stock.

Alertness to changing weather, particularly to shifting winds, is another characteristic of the successful foreman. He must judge accurately the speed and safety of firing and he must detect and suppress breakovers promptly. As shifts in wind directions occur he must be able to change his plans promptly and otherwise adjust the operation to changes in burning conditions.

Figure 2 illustrates the burning of a particular unit where the execution of the job conforms with the plan. Actually the plan is frequently changed by the foreman as a result of shifts in conditions. The ordinary steps in burning, illustrated in figure 2, are:

1.	Notify adjacent landowners of intention to burn.	
2.	Assembly of crew at designated starting point A.	4 p.m.
3.	The foreman discusses plans with crew, instructing each man in his individual duties.	4:15 p.m.
4.	Burning conditions tested by observation of a small spot fire (optional).	4:30 p.m.
5.	Spreading starts from selected starting point A.	5 p.m.
6.	Backfire is pushed through to completion before dark if possible.	5:40 p.m.
7.	Later, and with satisfactory winds, flank fires are spread at A and B along the external lines.	6-7:10 p.m.
8.	Where needed, supplementary flank fires may be set in internal lines.	6-7 p.m.
9.	As work progresses, burned-out line is mopped up.	7-11:30 p.m.
10.	Final mop-up is completed and crew leaves fire.	11:45 p.m.
11.	Fire is checked by a fresh patrolman not later than 8 a.m.	6-8 a.m.

In following the above, the leader must depend largely on his judgment in placing men and in deciding on action. Local weather conditions will govern the speed and efficiency of the work. As experience is acquired, the skill and judgment of the entire crew will grow until decisions will be made quickly and easily in response to variations in fuel and weather. Fire skillfully applied can never become a routine task, however. Its behavior is frequently surprising and never wholly predictable. Foresters have in fire a flexible and valuable tool if they can anticipate its vagaries and master its uses.

Every day's operation should be critically reviewed; mistakes and failures should be analyzed to prevent similar occurrences on other operations. Although final judgment of the success of the job will depend upon examination some weeks after the burning, certain damage will be obvious at the time of the burn. Often such damage can be prevented on succeeding units by planning and particularly by skillful laying of the fire.

Judging Results

The use of fire is recommended only where a careful analysis has shown the assumed benefits are clearly greater than the assumed losses and costs. Following the burning, a second analysis is desirable to better gage both benefits and losses. In the illustration on page 9 of this paper, the benefits and losses are compared. After the burning a similar analysis should be made using corrected costs and estimates of damage based on field examinations.

In judging the degree of success attained, the objectives of burning should be considered, and the degree to which they have been reached: Have fuel accumulations been reduced? Has a satisfactory barrier to fire spread been established? Have other objectives in the burning been attained?

Costs of the operations should also be analyzed carefully. During the first few weeks of burning, costs will often be high. Have costs been excessive in proportion to the benefits obtained through the use of extra men and special preparations? Can they be reduced without increasing damage to the point of eliminating the savings? How can costs on next year's operations be lowered?

Injuries to the stand should be determined through examination of an adequate sample. Estimates of defoliation and seedling and other mortality should be made. An experienced forest manager will not find the necessary cruising a difficult task, and the resulting data will be most helpful in guiding future work. All areas should be sampled representatively to get an appraisal in which both poor and good results are present.

No arbitrary value can be placed on seedlings killed. Their value is largely dependent on their position in the stand and the prevalence of other seedlings in the same locality. Slash pines remote from an existing seed source, for instance, are more valuable than trees of the same size and type where slash pine seed is abundant; likewise dominant, well-spaced trees have a higher value than crowded or understory trees.

Defoliation results in certain growth losses. Below the limit of one-third the crown, little loss has been measured. Above this point loss in growth is about in proportion to loss of foliage with total defoliation roughly equal to loss of 1 year's growth. By this rule, loss of two-thirds of the foliage would result in approximately half the normal increment in the stand for 1 year.

SUMMARY

In this paper, the principles governing the use of fire in the protection of longleaf and slash pine forests have been discussed and a general procedure for deciding on the wisdom of burning, and for planning and executing plans for fire use, has been described. The desirable steps in this procedure are: (1) An analysis to determine the desirability of use of fire; (2) the selection of a general plan or pattern of area to be treated; (3) an examination to locate burning units within this pattern; (4) the preparation of a sketch map for each burning unit; (5) the preparation of detailed plans for treating each unit; (6) treating the units as prescribed in the plans; (7) a critical review of the burning and its results.

In these recommendations, particular emphasis is placed on the analysis and planning of fire use. Voluminous paper work is undesirable, and the amount of detail should be kept to a minimum. It should be recognized, however, that the success of fire use depends principally upon a detailed knowledge of fuel and stand conditions. Frequently this phase of a successful program will require more time and energy from the supervisor than will the actual burning operation. Only by such analysis and preparation will the use of fire become a pointed and effective tool in the management of forest land in the longleaf-slash pine region.

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THE USE OF CHEMICAL STIMULANTS TO INCREASE GUM YIELDS IN SLASH AND LONGLEAF PINES

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U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

SOUTHERN FOREST EXPERIMENT STATION
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The Occasional Papers of the Southern Forest Experiment Station present information on current southern forestry problems under investigation at the Station. In some cases these contributions were first presented as addresses to a limited group of people, and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

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THE USE OF CHEMICAL STIMULANTS TO INCREASE GUM YIELDS IN SLASH AND LONGLEAF PINES

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INTRODUCTION

Chemical stimulation of gum flow in slash and longleaf pines started on an exploratory basis on the Olustee Experimental Forest in 1936. As there was no particular need for increased supplies of naval stores at that time, the work was conducted on a very limited basis. However, with the events which led to World War II and the accompanying increased demand for naval stores, this work was given strong impetus and the original studies were intensified and expanded. Considerable experimental data are now available on chemical stimulation, including the results which can be expected under field conditions. A description of these studies and the conclusions drawn from them are presented in this paper, which summarizes progress to date with particular emphasis on the work of 1942 and 1943.

HISTORICAL BACKGROUND

Following World War I, Germany and Russia initiated intensive programs to improve and expand their naval stores industries. It was during this initial period of expansion, when these countries were attempting to devise means of becoming self-sufficient in all important raw materials, that the use of chemicals to stimulate gum yields first received attention.

The Germans (12, 13, 17, 23) initiated studies in the use of chemicals to stimulate gum flow in 1933, and somewhat similar work was started in Russia (1, 30, 31, 32, 34) at about the same time. In these early exploratory experiments many different types of chemicals were used as liquids, solids, or gases, and included acids (organic and inorganic), bases, pure salts, various solvents, oxidizing and reducing agents, poisons, and relatively inert substances like alcohol, sugars, ether, and oils.

Many of the substances tested exhibited a stimulating action on the flow of gum. A few, such as sulphuric and hydrochloric acids, and sodium and potassion hydroxides, were outstanding. Much of the subsequent work has been with these chemicals. The small attention given the other chemicals does not preclude their potential value in stimulation, but indicates simply that in the concentrations tested, and under the experimental conditions prevailing, they did not cause as much increase in gum flow as the two acids and bases mentioned.

Many different techniques, as well as chemicals, were tried in the early European work. These included methods of applying chemicals, variations in chipping heights and depths, and different frequencies of treatment and chipping.

In this country the first work on chemical stimulation was started in 1936 as a cooperative study by the Southern Forest Experiment Station, U. S. Forest Service, at the Olustee Experimental Forest, Lake City, Fla., and the Bureau of Agricultural and Industrial Chemistry (formerly Bureau of Chemistry and Soils). Results of this early exploratory study were inconclusive. At that time there was a surplus of turpentine and rosin, prices were low, and there was little interest in chemical stimulation, but in 1938 a larger experiment was started to explore the possibilities further (18).

The promising increases in yield obtained in the 1938 experiment, even at the low concentrations in which the stimulants were used, gave further impetus to research and additional work on yield capacities of individual trees was done in 1940. These yield records served as the basis for dividing the trees into yield-capacity groups which were almost identical. Then in the 1941 season one group of trees was worked untreated, and the others assigned treatments which covered a wide concentration range of sulphuric and hydrochloric acids, the two chemicals giving best results in the former experiments. The results of this study (19, 20) formed an important link in the chain of evidence upon which recommendations to industry were made in 1942 (20) and 1943 (22).

Shortly after our entry into World War II an intensified research program on the use of chemical stimulants was instituted. This covered the use of many different chemicals in varying concentrations, numerous variations in chipping and treatment schedules, variations in height, depth, and frequency of chipping, studies on species differences, and the effect of chemicals on gum quality and the health and vigor of the trees. The results of this latest work are summarized in this paper and provide a basis for the latest recommendations to the industry (25). Further intensive tests are underway and additional data will be reported as available.

EXPERIMENTAL TECHNIQUES

In testing the influence of any treatment on yields from naval stores streaks, it has been found necessary to determine the natural yielding capacity of all trees and to arrange the trees into treatment groups of approximately the same capacity. The natural yielding capacity of trees varies not only with bole size and crown development but also with site and possible inherent qualities (27). The most effective manner of determining the yielding capacity of a tree was found to be through a calibration period of several weeks in which the tree is subjected to standard chipping practice and the yields carefully weighed. In these experiments it was found that the yielding capacity of a tree usually could be determined from 4 standard 1/2-inch streaks applied weekly. Both extremely high and extremely low producing trees were excluded from the treatment groups used in the studies.

Assignment of trees to treatment groups was done at random within each yield class, resulting in a moderately uniform distribution of trees of yielding capacities varying from the low to the high. The general yielding level of each group, before treatments started, was then essentially similar, so that differences observed in yield between groups could be attributed primarily to treatment. Enough replications were used for each treatment so that statistically significant yield differences greater than about 15 to 30 percent could be detected, the precision depending on the purpose of the specific experiment.

Species differences in response to chemical treatment were noted in early work, so most experiments were set up for both slash and longleaf pines in order to find the optimum treatment applicable to each. Second-growth stands of slash and longleaf of varying ages and diameters and chiefly of a single species were used in the tests, representing the range of timber types in the vicinity of Olustee, Fla.

Gum yields were obtained for each tree at regular intervals throughout the season, either weekly or biweekly; in one instance gum yields after 1 and 3 days were also obtained. This method provided data on the trend of yield response for individual trees as well as treatments. Valuable information on effective treatment periods was also obtained by this procedure.

Miscellaneous details of experimental technique include face widths one-third of the circumference on trees over 9 inches d.b.h., although standard uniform widths were used on all trees in certain experiments. Galvanized gutters and aprons were inserted with a broadax. Streaks were chipped 1/2-inch deep and 1/2-inch high, using a No. 0 hack unless otherwise specified. In the early work the chemical solution was applied with a brush, or glass cloth swab. Later a nasal-type spray atomizer was used. In more recent experiments chemicals were applied with a special spraygun equipped with a hand pump. All experiments were so designed as to allow for statistical examination of the data.

INVESTIGATIONAL WORK AND RESULTS

The general objectives of this research on chemical stimulants were to determine the best chemical treatments to increase the production of gum naval stores, and to develop methods for the use of chemicals adapted to conditions in the industry.

To accomplish these objectives numerous experiments were undertaken during the 1942 and 1943 seasons, covering many phases of chemical stimulation. Since some experiments were quite comprehensive, cross references will be made frequently under the separate headings in the following discussions.

The results from some of these studies are tentative in character, as only preliminary tests were made. In other instances the results are quite indicative of what may be finally expected, because supporting evidence is either available in replications in the station's work, or substantiated by workers in other countries. The qualifications applicable to each phase of study are pointed out in detail in the discussion so as to avoid erroneous conclusions.

Effectiveness of Different Chemicals

Many chemicals, some of which were tested at numerous concentrations, have been used during the last 10 years in attempts to increase gum yields by the use of chemical stimulants. The results have varied from an increase of about 250 percent to a decrease of almost 40 percent. Some chemicals have proven to be very consistent in their effect; others were variable. In general, strong acids and strong bases have been the classes of chemicals giving the best results, although some inorganic salts have indicated promise. Tables 1, 2, and 3 summarize the general results obtained with a variety of chemicals in Europe and at the Southern Forest Experiment Station.

The results of Kublun and others (table 1) show that a great many chemicals exert a stimulating effect on gum production in Scotch pine, Pinus sylvestris, varying markedly in intensify of effect for the different chemicals. The reported amount of stimulation is very high when compared to our results with slash and longleaf pines, but several factors are involved. Fundamental species differences in response to applied chemicals probably exist. Scotch pine is an extremely poor gum producer when judged by our slash or longleaf pine standards, or even by those for the maritime pine in France or the Aleppo pine in Spain and Portugal. Small increases loom larger, with a relatively small total amount involved, when expressed on a percentage basis. Thus an increase of 200 percent on a 50-barrel crop would amount to a total yield of 150 barrels, while on a 100-barrel crop (rather low by our standards) an increase of only 50 percent would result in the same total yield.

The fact that Scotch pine shows a positive response to many chemicals would appear to indicate a more sensitive species capable of response to a relatively weak stimulation. On the other hand slash and longleaf might be capable of a stronger "buffering" capacity in resisting change by added chemicals. The fundamental mechanism of response to applied chemicals may also contribute to this differential reaction.

All acids used caused some gum-flow stimulation at certain concentrations, but only two were consistently outstanding in promoting large increases in gum production, namely, sulphuric and hydrochloric acids. After initital experiments here and abroad, most subsecuent work concerned these two chemicals, which were used in a number of concentrations with variations in chipping techniques and treatment schedules. Other inorganic acids such as nitric and phosphoric were relatively ineffective at the lower concentrations but caused a considerable increase in gum flow at extremely high concentrations. It is difficult to reconcile the fact that sulphuric but not nitric acid brings about large increases in the flow of gum, although both are strong acids in a chemical sense. A number of inorganic acids had little effect on gum yields; these include boric, chromic, and perchloric acids. Organic acids, such as acetic, formic, lactic, picric, pyrogallic, and tannic acids, were relatively ineffectual. Certain growth substances such as indoleacetic, indolebutyric, and naphthaleneacetic acids in the strengths and combinations used gave little promise of stimulating gum yields markedly.

Early work also showed that strong bases, such as sodium and potassium hydroxides, resulted in greatly augmented gum yields, while ammonium hydroxide, a weak base, was only effective at a very high concentration. This held true for Scotch, slash, and longleaf pines.

Both strong acids and strong bases at relatively high concentrations were thus found to be effective stimulants of gum yields. That both classes of chemicals should work almost precludes certain theories of "acidity" in explaining the basic action involved in chemical stimulation, although changes in acidity of tissue immediately above the face probably plays an important role.

Many salts were used, ranging from common table salt, sodium chloride, to corrosive or poisonous chemicals like potassium bichromate, ammonium thiocyanate, and arsenic pentoxide, but relatively small yield responses were obtained. Other relatively inert substances like alcohol, glycerine, and sugar were in this same category. At other concentrations, and other means of application, some of these may prove more effective, and work is being continued on a moderate scale on their use.

Table 1.—Results of several foreign investigations on the use of chemicals to stimulate gum yields in Scotch pine, *Pinus sylvestris*

Investigator and chemicals tested	Percent concentration	Percent increase in yield: Streak 1	Streak 2
KUBLUN (17)			
Acetic acid	10	29	10
Acetic acid	50	36	*
Acetic acid	conc.	46	*
Formic acid	10	52	23
Formic acid	50	62	*
Formic acid	conc.	60	*
Lactic acid	50	57	21
Lactic acid	90	49	37
Ethyl-sulphuric acid	25	74	76
Ethyl-sulphuric acid	50	92	89
Sulphuric acid	10	15	14
Sulphuric acid	25	30	82
Sulphuric acid	50	123	118
Hydrochloric acid	10	17	32
Hydrochloric acid	25	118	107
Hydrochloric acid	33	109	100
Lactic acid	25	33	15
Phosphoric acid	20	*	26
Boric acid	3	79	68
Potassium hydroxide	10	13	45
Potassium hydroxide	20	57	100
Sodium chloride	10	*	22
Potassium chloride	10	*	37
Potassium chloride	40	20	32
Potassium carbonate	40	32	40
Hydrogen peroxide	3	8	22
Phenol	5	*	11
		Season	
Nitric acid	10	61	
Nitric acid	25	32	
Nitric acid	50	75	
Alcoholic acetic acid	25	23	
Alcoholic acetic acid	50	29	
Alcoholic formic acid	25	39	

*Indicates no difference or decrease

Table 1.—continued

Chromic acid	20	44
Tannic acid	20	25
Boric acid	3 parts	59
Sulphuric acid	10 parts	
Alcohol	10 parts	
Boric acid	3 parts	6
Sulphuric acid	10 parts	
Alcohol	10 parts	
Water	10 parts	
Sulphuric acid	5 parts	59
Potassium bichromate	1 part	
Water	4 parts	
Alcoholic potassium hydroxide	10	16
Ammonia hydroxide	10	7
Ammonia hydroxide	20	50
Sugar	5	41
Alum	10	12
Sodium acetate	20	43
Sodium formate	20	38
Alcohol	50	*
Alcohol	95	*
Glycerine	conc.	21
NIKOLAEV & SINELOBOV (31)		
Chlorine gas	--	increases
Sulphuric gas	--	increases
NIKOLAEV & SINELOBOV (32)		
Sulphuric acid	60	144 (average)
Sulphuric acid	conc.	250 (approx.)
Hydrochloric acid	conc.	103 (average)
HESSENLAND (12)		
Sulphuric acid	50	128
Alcoholic sulphuric acid	50	104
Hydrochloric acid	10	32
Hydrochloric acid	25	115
Formic acid	6	67
Potassium hydroxide	10	45
Potassium hydroxide	20	111
Ammonia hydroxide	10	7
Ammonia hydroxide	20	50
Sodium chloride	10	22
Calcium chloride	40	37

*Indicates no difference or decrease

Table 2.- Gum yields of longleaf pine treated with various chemicals during portions of the 1942 season using 1/2-x 1/2-inch chipping at the Olustee Experimental Forest

Chemical treatment	Percent concentration	Percent increase (+) or decrease (-)
Acetic acid	5	-19
Acetic acid	20	-28
Ammonium hydroxide	5.6	-13
Ammonium hydroxide	14	+ 4
Ammonium hydroxide	28	+39
Ammonium sulphamate	2.5	+18
Ammonium sulphamate	5	- 5
Ammonium sulphamate	10	+20
Ammonium sulphamate	25	- 6
Ammonium sulphamate	40	-27
Ammonium thiocyanate	2	-24
Ammonium thiocyanate	5	-25
Ammonium thicyanate	10	-17
Arsenic pentoxide	18.8	+ 7
Arsenic pentoxide	37.5	+27
Arsenic pentoxide	75	± 0
Arsenic trioxide	0.15	-18
Arsenic trioxide	0.3	- 8
Arsenic trioxide	0.6	-12
Borax-boric acid	10	- 9
Borax-boric acid	20	- 9
Borax-boric acid	30	+10
Ethylene chlorhydrin	5	- 3
Ethylene chlorhydrin	10	- 1
Ethylene chlorhydrin	20	- 2
Formaldehyde	10	- 4
Formaldehyde	25	+ 4
Formaldehyde	40	-34
Growth substances:		
Indolebutyric acid	50 ppm	- 9
Indoleacetic acid	25 ppm	
Naphthaleneacetic acid	25 ppm	
Mercuric chloride	1	-12
Mercuric chloride	2	-16
Nitric acid	20	-16
Nitric acid	33	-18
Nitric acid	50	+10
Perchloric acid	5	-14

Table 2. - continued

Perchloric acid	10	± 0
Perchloric acid	20	+10
Phenol	1.4	- 7
Phenol	2.3	-16
Phenol	7	- 9
Phosphoric acid	30	- 4
Phosphoric acid	45	+ 8
Phosphoric acid	90	+29
Picric acid	0.17	+10
Picric acid	0.35	-12
Picric acid	1.4	- 6
Potassium hydroxide	5	- 3
Potassium hydroxide	10	- 4
Potassium hydroxide	20	+17
Potassium hydroxide	40	+38
Pyrogallic acid	5	-36
Silver nitrate	2.5	- 9
Silver nitrate	5	-13
Sodium chlorate	2	- 7
Sodium chlorate	5	- 3
Sodium chlorate	10	+12
*Sulphuric acid + arsenic pentoxide	1 and 1	+20
Sulphuric acid + arsenic pentoxide	1 and 2	+16
Sulphuric acid + arsenic pentoxide	5 and 1	- 4
Sulphuric acid + arsenic pentoxide	5 and 2	- 4
Sulphuric acid + arsenic pentoxide	10 and 1	+ 8
Sulphuric acid + arsenic pentoxide	10 and 2	+10
Sulphuric acid + arsenic trioxide	40 and 0.20	+55

*For more complete information on results with sulphuric acid see table 3; and for chemical combinations see table 4.

Table 3. - Gum yields of slash and longleaf pines receiving chemical treatments with the most promising stimulants at the Olustee Experimenal Forest*

Chemical treatment	Percent concentration	Percent increase (+) or decrease (-)	
		Slash	Longleaf
Weekly chipping and treatment			
Hydrochloric acid	8	+34	-30
Hydrochloric acid	16	+50	- 2
Hydrochloric acid	24	+45	+ 7
Hydrochloric acid	28	--	+ 9
Hydrochloric acid	32	--	+21
Hydrochloric acid	35	--	+ 1
Sulphuric acid	5	-18	-14
Sulphuric acid	20	+28	-12
Sulphuric acid	30	+29	-12
Sulphuric acid	40	+63	+35
Sulphuric acid	60	+68	+60
Sulphuric acid	75	--	+44
Sulphuric acid	90	--	+54
Sodium hydroxide	5	+ 8	+16
Sodium hydroxide	15	+41	+25
Sodium hydroxide	25	+37	+38
Sodium hydroxide	50	--	+66
Biweekly chipping and treatment**			
Sulphuric acid	40	+22	- 8
Sulphuric acid	60	+20	+ 9
Sodium hydroxide	5	-26	-40
Sodium hydroxide	25	-19	-25
Triweekly chipping and treatment**			
Sulphuric acid	40	- 9	-56
Sulphuric acid	60	-26	-28
"Skip" - weekly chipping and biweekly treatment			
Sulphuric acid	40	+45	+32
Sulphuric acid	60	+41	+44
Sodium hydroxide	5	+19	- 9
Sodium hydroxide	25	+25	+ 7

*Percent increase or decrease based on untreated controls chipped 1/2- x 1/2-inch weekly.

**Biweekly and triweekly refers to chipping and/or treatment at two- or three-week intervals.

Table 4. - Gum yields of slash and longleaf pines chipped weekly and treated with various chemical combinations

Species, type of chipping, and chemical treatment*	No. of streaks	Av. yield in grams	Percent increase
Longleaf I (Regular 1/2- x 1/2-inch chipping)			
Untreated	10	925	--
40% Sulphuric acid, H_2SO_4	10	1053	13.9
40% H_2SO_4 + 0.958% Cupric sulphate	10	1029	11.2
40% H_2SO_4 + 1.821% Potassium aluminum sulphate	10	1346	45.5
40% H_2SO_4 + 0.619% Zinc sulphate	10	1206	30.3
Longleaf II (Regular 1/2- x 1/2-inch chipping)			
Untreated	21	1969	--
40% Sulphuric acid, H_2SO_4	21	2501	27.0
40% H_2SO_4 + 0.998% Sodium arsenite	21	3049	54.9
Slash I (Regular 1/2- x 1/2-inch chipping)			
Untreated	15	1562	--
40% Sulphuric acid, H_2SO_4	15	2404	53.9
40% H_2SO_4 + 0.998% Sodium arsenite	15	2890	84.9
25% Sodium hydroxide, NaOH	15	2233	42.9
25% NaOH + 0.998% Sodium arsenite	15	2271	45.4
Slash II (Bark chipping 1/2 inch high)			
Untreated	9	815	--
40% Sulphuric acid, H_2SO_4	9	1391	70.6
40% H_2SO_4 + 0.523% Potassium phosphate	9	1614	97.9

*Twentieth molar concentrations of added chemicals were used in this preliminary work, thus the expression of concentration in percent results in decimal figures.

Effectiveness of Chemical Combinations

Certain chemical combinations, involving the use of two or more chemicals in the same solution, give promise of being even better than the single chemical solutions tested to date (table 4). This effect has been synergic in more than one instance, the stimulation results being more than additive for the chemicals used, and is typified by the yields obtained with acid plus arsenic (38) as indicated in table 2.

Three of the four chemical combinations tried on longleaf pine appear to have promise as effective yield stimulants. With slash pine two of the three chemical combinations used resulted in yield increases greater than those obtained with sulphuric acid alone. All were considerably above the level of increase obtained with 40-percent sulphuric acid. This is particularly noteworthy since concurrent work showed that in general 40-percent is not nearly as effective as 60-percent sulphuric acid on longleaf. The increased yields obtained with these chemical combinations approached the best resulting from 60-percent sulphuric acid treatment.

The acid-arsenic solution gave good results on both pine species with regular chipping 1/2 inch deep and 1/2 inch high. Phosphorous added to sulphuric acid also gave a greatly augmented yield response on slash pine with bark chipping 1/2 inch in height. Added zinc sulphate increased yields somewhat on longleaf, while potassium aluminum sulphate resulted in even greater yield increases almost equal to those with acid-arsenic. The latter appeared best on longleaf, among the chemicals tried, as far as increased yields were concerned. The value of added arsenic in chemical stimulation techniques is enhanced by its influence in inhibiting iron corrosion (38).

An acid-arsenic solution was first chosen because of its being an inhibitor of iron corrosion (4). The success of this combination in a subsequent preliminary test of its effect on yields led to trials of the other combinations listed. The choice of the specific chemicals used was based on their relative closeness in the group of elements called heavy metals, and their chemical behavior, particularly as catalysts in certain reactions. Others in the same group, such as antimony, bismuth, and selenium were not used for reasons of availability, cost, and possibly lower reaction rates.

These results, although indicating great promise for chemical combinations, are preliminary in character. They are based on only one season of work and are far short of encompassing the enormous range of possible combinations of chemicals and concentrations that may be tested. Further work on a moderate scale is under way.

Table 5. - Yield results for three years of chemical stimulation with weekly 1/2- x 1/2-inch chipping on slash pine

Chemical treatment	Av. yield in grams 1940**	Percent increase in yield* 1941	1942	1943
Untreated***	3585	3790	3676	3606
20% Sulphuric acid	3585	28	22	20
30% Sulphuric acid	3585	29	9	11
40% Sulphuric acid	3585	47	17	18
8% Hydrochloric acid	3585	34	13	14
16% Hydrochloric acid	3585	50	26	23
24% Hydrochloric acid	3585	45	14	10
Washing soda	3585	9	6	--

*Seasons: 1940 - April 2 to November 5, 32 streaks; 1941 - April 1 to November 4, 32 streaks; 1942 - April 8 to December 9, 35 streaks; 1943 - April 5 to November 15, 32 streaks.
**Chipped weekly all season without chemical treatment for purposes of calibration.
***Average yield in grams of untreated control for each year of working.

Table 6. - Yield results for study of variations in frequency of chipping with different chemical treatments on slash pine

Chemical treatment	Frequency of chipping	1942 (16 streaks) Average yield in grams*	1942 Percent increase or decrease	1943 (32 streaks) Average yield in grams*	1943 Percent increase or decrease
Untreated	Weekly	2094	--	4459	--
5% NaOH	Weekly	2267	+ 8	--	--
15% NaOH	Weekly	2952	+41	4949	+11
25% NaOH	Weekly	2866	+37	5256	+18
60% H_2SO_4	Weekly	3526	+68	6379	+43
5% NaOH	Biweekly	1554	-26	--	--
25% NaOH	Biweekly	1698	-19	3132	-30
40% H_2SO_4	Biweekly	--	--	4567	+ 2
60% H_2SO_4	Biweekly	2117	+ 1	4318	- 3
5% NaOH	Skip	2484	+19	--	--
25% NaOH	Skip	2620	+25	5314	+19
40% H_2SO_4	Skip	3032	+45	6388	+43
60% H_2SO_4	Skip	2945	+41	5921	+33
40% H_2SO_4	Triweekly	--	--	4047	- 9
60% H_2SO_4	Triweekly	--	--	3296	-26

*Average yield in grams for season (1942 - August 13 to November 26; 1943 - April 6 to November 16); all percents are calculated on basis of 1/2 x 1/2 inch untreated weekly chipping.

Table 7. - Yield results for study of variations in frequency of chipping with different chemical treatments on longleaf pine

Chemical treatment	Frequency of chipping	1942 (16 streaks) Average yield in grams*	1942 (16 streaks) Percent increase or decrease	1943 (32 streaks) Average yield in grams*	1943 (32 streaks) Percent increase or decrease
Untreated	Weekly	1406	--	2675	--
5% NaOH	Weekly	1634	+16	--	--
15% NaOH	Weekly	1761	+25	3035	+13
25% NaOH	Weekly	1942	+38	3257	+22
40% H_2SO_4	Weekly	--	--	3617	+35
60% H_2SO_4	Weekly	2061	+47	2962	+11
5% NaOH	Biweekly	850	-40	--	--
25% NaOH	Biweekly	1057	-25	1873	-30
40% H_2SO_4	Biweekly	1298	- 8	1885	-30
60% H_2SO_4	Biweekly	1531	+ 9	2274	-15
5% NaOH	Skip	1276	- 9	--	--
25% NaOH	Skip	1509	+ 7	2829	+ 6
40% H_2SO_4	Skip	1856	+32	3011	+13
60% H_2SO_4	Skip	2022	+44	2990	+12
40% H_2SO_4	Triweekly	--	--	1185	-56
60% H_2SO_4	Triweekly	--	--	1914	-28

*Average yield in grams for season (1942 - August 21 to December 4; 1943 - April 6 to November 17): All percents are calculated on basis of 1/2- x 1/2 inch untreated weekly chipping.

Importance of Chemical Concentration

Increased concentrations of effective chemicals result in maximum increases in gum yields, but this higher level of gum yield is not maintained over a very long period. For instance, when extremely high concentrations of sulphuric acid are used, such as 75, 90, or 96 percent (concentrated), immediate gum yields are generally very much greater for several streaks. This high yield level usually decreases shortly to that for lower concentrations, possibly because of temporary damage to the living tissue for some distance above the face, or because of a relatively sudden depletion of oleoresin below the level of synthesis supply. It has also been found that a moderate concentration, such as 60 percent on slash pine, brings about good results the first season but appears to be less effective during successive years. This is illustrated in tables 5 to 7, inclusive. Important factors concerned with these lowered yield increases in succeeding years are discussed later under "Effective Treatment Period."

Increasing the amount of chemical applied influences yields in a manner similar to that of increasing concentration. Results with heavy application at weaker concentrations are relatively comparable to light application at higher concentrations. This probably holds true when we consider the total amount applied to the streak, as well as the completeness of coverage obtained. These factors are covered adequately in a recent publication by Dorman, True, and Clements (6). This was also emphasized in another experiment (table 8) where considerable care was taken to obtain adequate and complete coverage of the face in applying acid. Increases of over 100 percent in gum yield resulted from this careful treatment; this is considerably more than resulted from only average care in treatment as indicated in tables 5 to 7, inclusive.

Table 8. - Yield increases in slash pine obtained with careful treatment

Type of cupping	Type of chipping	Chemical treatment	Av. weekly yield in grams	Percent of untreated
Virgin face	Regular 1/2 x 1/2 inch	Untreated	105	100
Virgin face	Regular 1/2 x 1/2 inch	40% H_2SO_4	232	221
Back face	Regular 1/2 x 1/2 inch	Untreated	98	100
Back face	Regular 1/2 x 1/2 inch	40% H_2SO_4	168	171
Back face	Bark chip. 1/2 inch ht.	40% H_2SO_4	214	218

Choice of the optimum concentration for any one species treated on a given schedule must depend on the integration of all factors concerned. These include frequency of application, the effect on yields during successive years of treatment, and thoroughness of application. All of these were considered before making the recommendations reported by Mitchell (25). He states that ". . . a 40 percent solution of sulphuric acid is most effective on slash pine, whereas a 60 percent solution works best on longleaf pine. Thus, for best results, use a 40 percent solution on pure or predominately slash pine timber, and a 60 percent solution on pure or predominately longleaf pine timber. If the two species are equally represented, or nearly so, use the 60 percent solution."

Frequency of Chemical Treatment and Chipping

The action of applied chemical stimulants appears to be expressed more in prolongation of gum flow than in initial acceleration. Figure 1 indicates the general type of response for a typical weekly interval, and figures 2 to 5 show ~~that~~ the yield results for longer periods.

The average amount of gum exuded during the first 48 hours following chipping (fig. 1) is essentially the same for treated and untreated trees. The basic data for figure 1 were obtained with continuous-recording gum-flow meters (21), thus making it possible to determine that both the treated and untreated streaks show the typical diurnal rise and fall in rate of flow, running more during the day and decreasing at night. After about the first two days the average daily yield of gum from untreated trees gradually diminishes from day to day (11, 21). The flow of gum from treated trees, on the other hand, continues at approximately the same rate for a much longer time and only after weeks, instead of days, does the daily gum output decline to negligible amounts (fig. 5).

It is evident, from the trends exhibited by different frequencies of chipping and chemical treatment, that a proportionately greater amount of gum can be obtained from chemically treated streaks, than from untreated streaks chipped at intervals greater than one week. Figure 2 shows that essentially the same amount of gum can be obtained in 2 weeks from a single acid-treated streak as from two untreated streaks put on at weekly intervals, and (in this case) almost 80 percent more gum than from a single untreated streak during the same interval. On a triweekly basis of chipping and treatment (fig. 3) almost as much gum can be obtained as if the trees were chipped at weekly intervals. When chipped every 4 weeks, as illustrated in a typical experiment shown in figure 4, the yield from treatment is about double that obtained without applied chemicals. Diminishing returns follow at longer chipping intervals, since after 8 weeks (fig. 5) there was an increase of only 120 percent as a result of treatment. This latter is of theoretical interest only, however, as such long chipping intervals are not economically practical, and would not be recommended for general use.

Thus, there is a definite interval of chipping and treatment that will result in maximum yields consistent with the amount of labor expended. The only full season's results available now for different intervals are for weekly, biweekly, and triweekly chipping and treatment (tables 6 to 9, inclusive). The biweekly results (tables 6 and 7) for a whole season's treatment with acid substantiate the trend shown in figure 2, i. e., just as much gum during 14 days from a single acid-treated streak as from two

weekly untreated streaks. Although no adequate basis for a comparison of the triweekly results is available in the chemical stimulation data, ample yield records are available from previous experiments. These provide a good basis for estimating ratios of treatment yields to untreated streaks at various intervals of chipping.

These are the basic data for Mitchell's 1944 recommendation (25) for periodic acid treatment: ". . . applying sulphuric acid, immediately after chipping, to all streaks chipped during the spring and summer months." As he points out, maximum total production for a season may be obtained by chipping and treating the entire croppage on the average of once each week, but under conditions of labor shortages more gum may be obtained by applying acid each time a tree is chipped, regardless of the frequency of chipping.

An interesting variation in chipping and treatment schedules, where considerable yield increases over regular weekly untreated chipping were obtained, is the "skip treatment," in which a tree is chipped each week, with acid being applied every other week, (tables 6 and 7). This treatment is the only one showing consistently high yield increases the second season, with the extra gum yields approaching, but not quite equaling, weekly chipping with acid treatment.

This discussion so far has dealt with acid treatment. A strong base, such as sodium hydroxide, does not prolong the flow of gum for much longer than one week. No daily gum-flow measurements were made with base treatment, but repeated weekly weighings with biweekly chipping and treatment with sodium hydroxide indicated that over 80 percent of the increased yield came in the first week. It has also been noted that a number of treated streaks (using sodium hydroxide) must be put on before yield increases are built up to a maximum. These facts restrict the use of sodium hydroxide to a regular weekly chipping and treatment schedule in order to obtain maximum yields for the labor expended.

FIGURE NO. 1

FIGURE NO. 1

ACCUMULATIVE HOURLY GUM YIELDS OF SLASH PINE WITH AND WITHOUT TREATMENT WITH 40% H_2SO_4

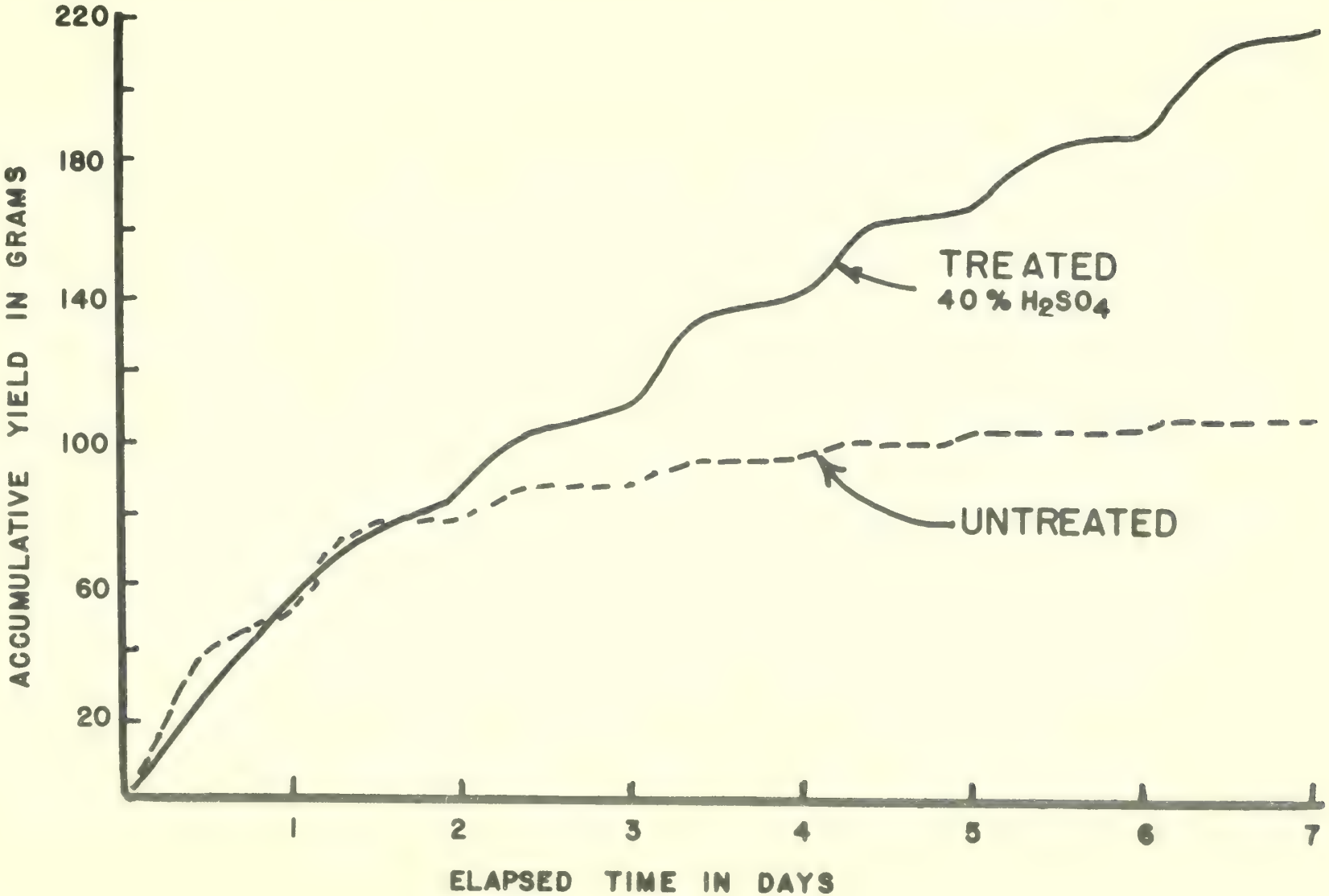


FIGURE NO. 2

ACCUMULATIVE DAILY GUM YIELDS OF ONE TREATED AND TWO UNTREATED STREAKS FOR A TWO WEEK PERIOD — LONGLEAF PINE — 24% HCL

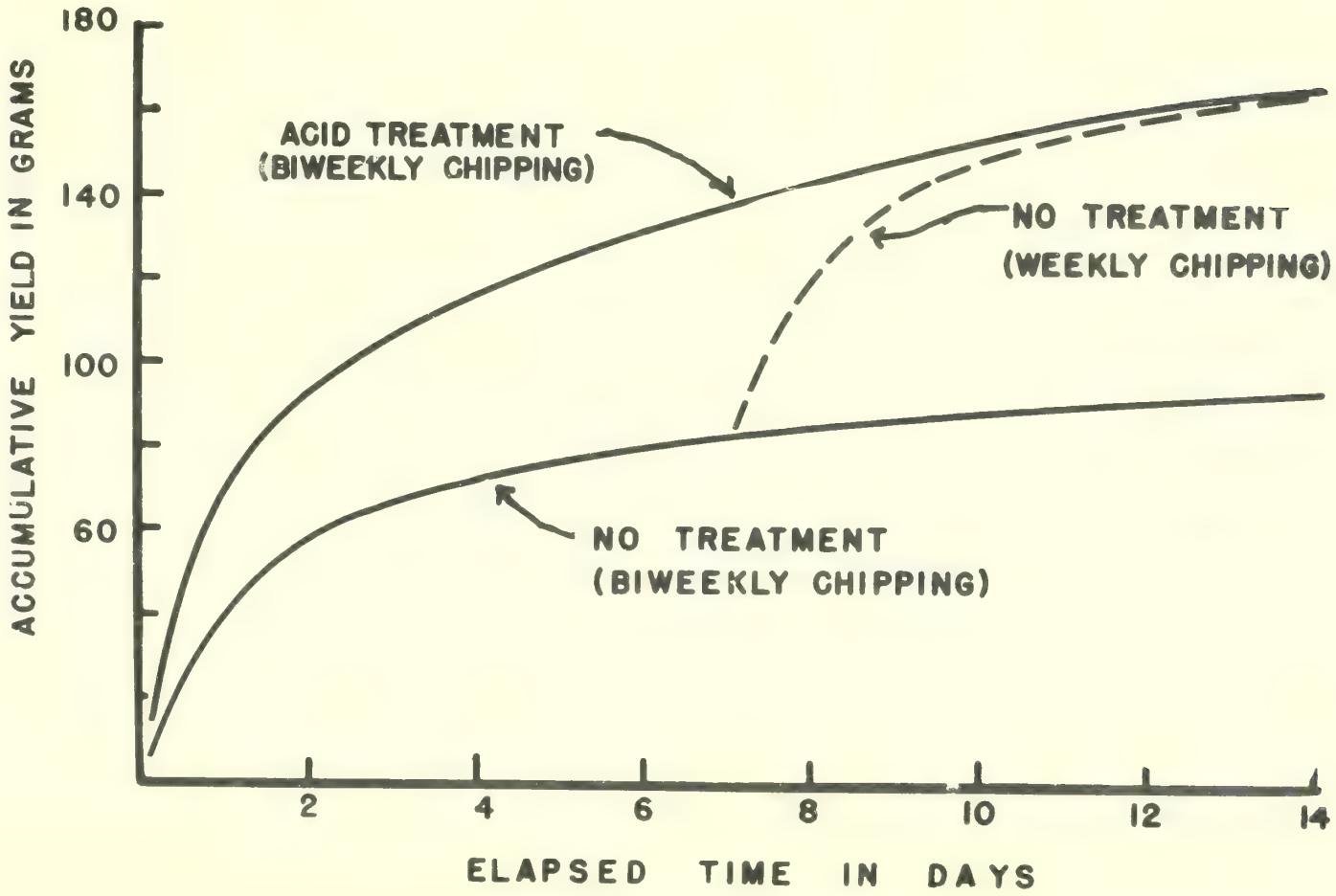


FIGURE NO. 3

COMPARATIVE GUM YIELDS OF UNTREATED WEEKLY CHIPPING WITH TRIWEEKLY CHIPPING AND TREATMENT

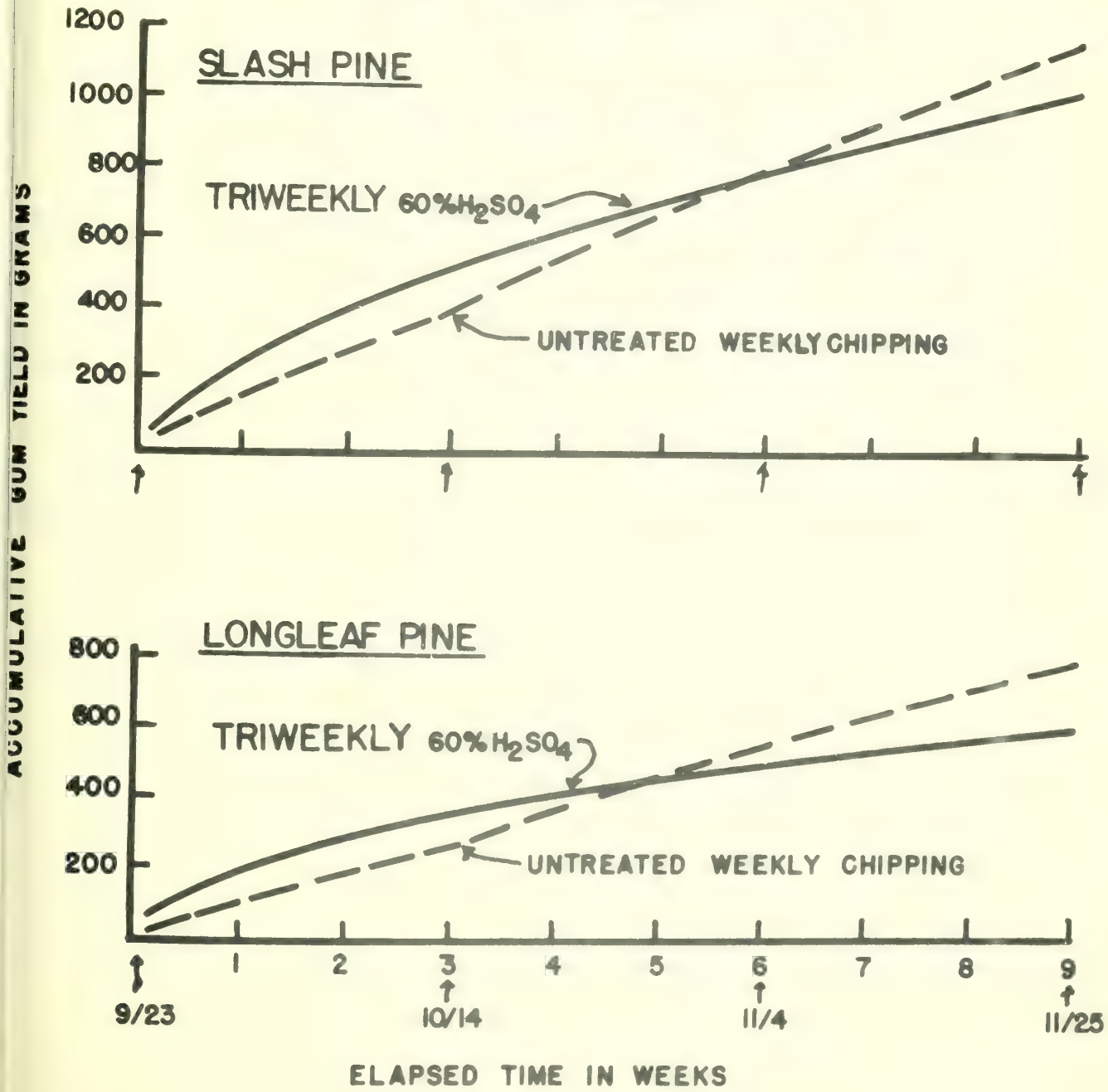


FIGURE NO. 4

ACCUMULATIVE DAILY GUM YIELDS FOR A PERIOD OF 4 WEEKS FOLLOWING TREATED AND UNTREATED CHIPPING LONGLEAF PINE

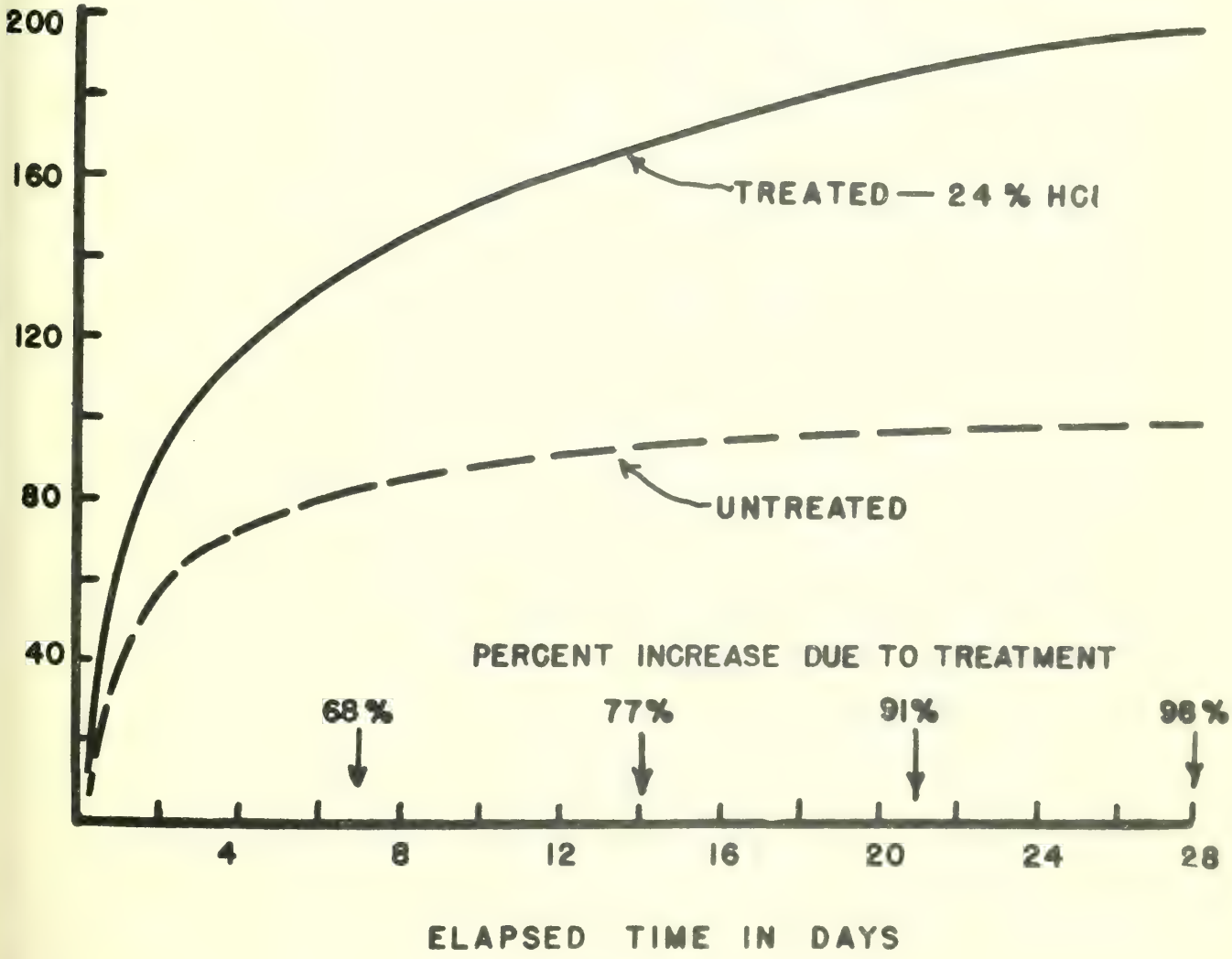
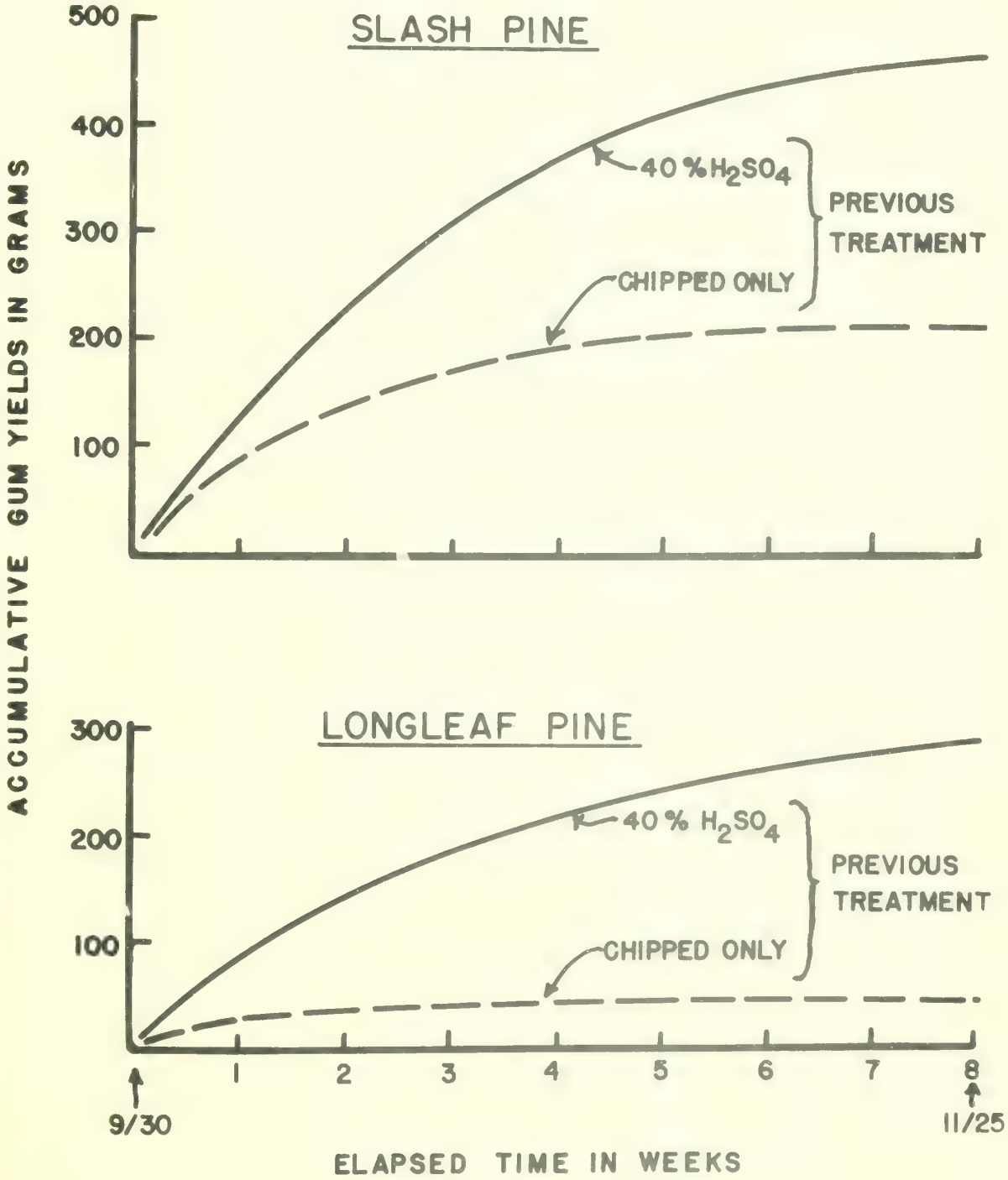


FIGURE NO. 5

COMPARATIVE WEEKLY GUM YIELDS FOLLOWING 4 CONSECUTIVE WEEKS OF CHIPPING & TREATMENT



Depth and Height of Chipping with Chemical Stimulation

Current accepted practice in height and depth of chipping is not static, but streaks about 1/2 inch in depth and 3/8 to 1/2 inch in height are the most commonly used. With chemical stimulation a need arose for a further study of variations in height and depth of chipping using different chemicals at different concentrations, and of the concurrent effect of frequency of chipping. Preliminary studies in 1942 led to the 1943 experiment on depth, height, and frequency of chipping summarized in tables 9 and 10.

Only tentative conclusions can be drawn from these results because in general only yields for 1 year are represented, and further desirable variations in height of chipping (with and without treatment) will not be available until later. However, a number of important relationships are indicated, with one particular treatment being outstanding.

Statistical analysis of the data for height of chipping, for all treatments combined, showed that the 1/4-inch height gave significantly less gum than either 1/2 or 3/4 inches, with no significant difference in yields between the two latter heights. Examination of individual treatment totals for the various heights reveals several interesting relationships, but these are mainly only trends and need further clarification that will be provided by current work. Treatment with sodium hydroxide on a weekly or biweekly schedule showed no definite trend differences (except for generally low yields for 1/4-inch height) for any of the variations in height and depth of chipping. A slight trend of small yield increases, with weekly or biweekly chipping and treatment with sulphuric acid, was indicated for the 3/4-inch height over 1/2-inch height chipping for all depths, but these increases were too small to be significant. Thus, on the basis of these experiments, chipping 1/2 inch in height appears to be the most efficient in terms of seasonal face height and maximum gum yields.

The most important outcome of these experiments was the revelation that bark chipping, which is the removal of the outer and inner bark tissues down to but not including the wood, combined with treatment with sulphuric acid, consistently gave greater yields than any other treatment combination used. Preliminary results in 1942 indicated that bark chipping 1/2 inch in height treated with 40-percent sulphuric acid consistently resulted in greater yields than regular acid-treated chipping 1/2 inch in depth and 1/2 inch in height. The experiments reported in tables 9 and 10 substantiated the preliminary conclusions, and these were further strengthened by the results of separate experiments indicated in table 8. All these formed the basis for the statements made in reporting a preliminary model of a tool designed especially for bark chipping (37). Continuation of these experiments, and more intensive current trials of height variations, will provide a more adequate basis for judging optimum heights of chipping with chemical treatment and bark chipping.

Table 9. - Yield results with variations in frequency, depth, and height of chipping using different chemical stimulants for the 1943 season with slash pine

Chemical treatment	Frequency of chipping*	BC** depth			1/2 inch depth			3/4 inch depth		
		1/4 inch height	1/2 inch height	3/4 inch height	1/4 inch height	1/2 inch height	3/4 inch height	1/4 inch height	1/2 inch height	3/4 inch height
		Percent increase or decrease								
Untreated	Weekly	-32	- 8	-23	- 9	3999***	- 1	+ 9	+ 3	+ 5
25% NaOH	Weekly	- 2	+19	+26	+42	+33	+19	+ 4	+26	+10
40% H_2SO_4	Weekly	--	+29	+72	--	+40	+58	--	+44	+44
60% H_2SO_4	Weekly	--	+50	+54	--	+53	+15	--	+24	+63
25% NaOH	Biweekly	-53	-38	-31	-25	-38	-30	-40	-12	-38
40% H_2SO_4	Biweekly	--	- 8	+22	--	- 7	+ 9	--	- 9	-15
60% H_2SO_4	Biweekly	--	-27	+ 7	--	+20	- 7	--	- 1	+ 5

*Biweekly chipping refers to applying a streak every 2 weeks.
**Bark chipping - chipped through bark to wood.
***Average yield in grams for untreated control for 30 streaks (April 15 - November 4, 1943). All other figures indicate the percentage increase or decrease in yields compared with this as the control.

Table 10. - Yield results with variations in frequency, depth, and height of chipping using different chemical stimulants for the 1943 season with longleaf pine

Chemical treatment	Frequency of chipping*	BC** depth			1/2 inch depth			3/4 inch depth		
		1/4 inch height	1/2 inch height	3/4 inch height	1/4 inch height	1/2 inch height	3/4 inch height	1/4 inch height	1/2 inch height	3/4 inch height
		Percent increase or decrease								
Untreated	Weekly	-33	- 5	-22	-21	2853***	+ 4	-21	-12	- 2
25% NaOH	Weekly	+10	+ 5	+23	+17	+10	+26	+ 8	+31	+45
40% H_2SO_4	Weekly	--	+44	+55	--	+ 6	+18	--	+56	+19
60% H_2SO_4	Weekly	--	+78	+64	--	+60	+49	--	+14	+53
25% NaOH	Biweekly	-38	-38	-38	-45	-39	-40	-42	-35	-39
40% H_2SO_4	Biweekly	--	+30	+ 9	--	-14	-20	--	-32	- 3
60% H_2SO_4	Biweekly	--	+13	+16	--	- 9	- 6	--	- 9	- 6

*Biweekly chipping refers to applying a streak every 2 weeks.
**Bark chipping - chipped through bark to wood.
***Average yield in grams for untreated control for 30 streaks (April 23 - November 12, 1943). All other figures indicate the percentage increase or decrease in yields compared with this as the control.

Effective Treatment Period

An important factor directly concerned with the continued successful and profitable use of chemical stimulants in successive years of working is the effective treatment period. This may be defined as that period during which a given chemical treatment and chipping schedule will result in maximum gum yields consistent with the effort expended. The two most important features affecting this period are the intensity and duration of chemical treatment.

The magnitude of the extra gum yield associated with the application of a chemical stimulant increases as the season advances (fig. 6). Studies of seasonal trends based on weekly chipping with acid treatment indicate that increased yields due to applied chemicals reach a maximum a little past mid-season. A sharp decline in effectiveness of applied chemicals begins to occur after about 20 treated streaks, and eventually reaches a point at which no significant yield increases are obtained. This pertains particularly to the more intensive treatments such as weekly chipping with acid. Thus there is a period of as much as 10 weeks at the end of the season when little or no extra gum yield is obtained due to applied chemicals. The length of this period may vary because of a number of circumstances which include the time chipping and treatment starts in the spring, the number of treated streaks, the intensity of treatment, and seasonal variations.

When chipping and treatment are started in late spring and early summer, the decline in increased gum production usually comes later in the year, but in any event occurs several weeks before the end of the season. The number of treated streaks probably plays the biggest role here in that the more treated streaks put on before the time of the natural seasonal decline, the sooner the reduction in the magnitude of yield increases. The converse is also true. The fewer treated streaks each tree receives before reaching the usual point of diminishing gum yields, the more prolonged is the period of increased gum flow. Intensity of treatment, however, may modify this trend, since usually the more intensive treatments, although resulting in maximum gum production, have a shorter effective treatment period. Weekly chipping with acid treatment falls in this latter category. A less intensive treatment is the "skip" schedule with weekly chipping and acid treatment of every other streak. The use of stronger acid concentrations and complete thoroughness of application would also contribute to a more intensive treatment and tend to shorten the effective treatment period. Weather conditions which change the usual seasonal trends also probably influence the length of the period in which applied chemicals are effective.

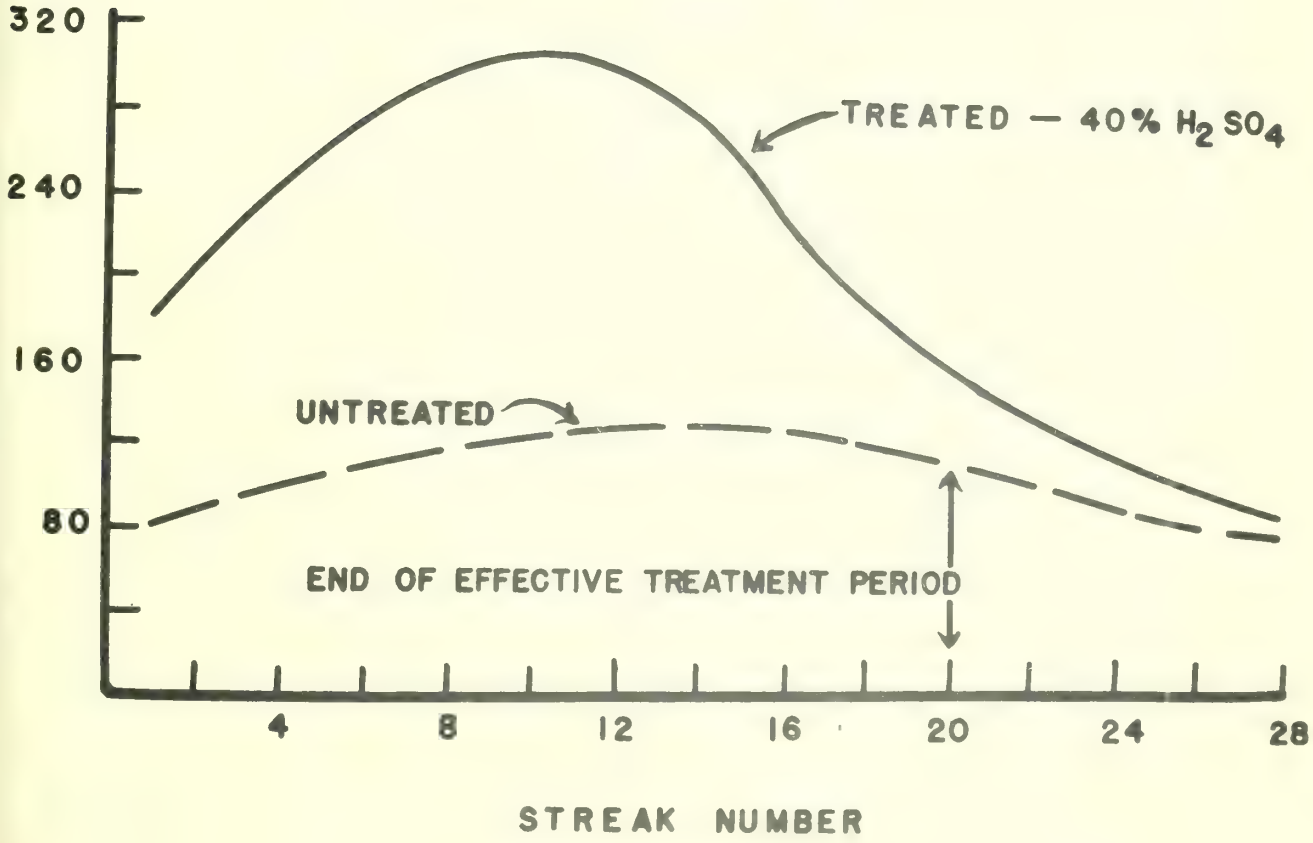
Intensive treatments, besides their influence on the end of the effective treatment period, also affect the results at the beginning of the next season's work. For instance, if the intensity of the previous season's chemical treatment has been high, then the yields of the first few treated streaks generally will not be above those of the untreated streaks. Most factors affecting the duration of effective treatment period also affect the number of initial unproductive treated streaks put on in the spring. Several possible factors are concerned in this "carry-over" result, and fortunately a procedure is available to reduce this unproductive initial period.

FIGURE NO. 6

SEASONAL TRENDS IN AVERAGE WEEKLY GUM YIELDS

FROM TREATED AND UNTREATED TREES

SLASH PINE



The trees in the experiment reported in table 5 received, for the first time, three untreated weekly chippings at the end of the 1943 season. This resulted in the removal of most of the wood seriously affected by acid treatment during 1943. It is significant that the first four treated streaks in 1944 receiving the 40-percent sulphuric acid showed a large increase in yield. This was the first time this had occurred, as the first three or four treated streaks in 1942 and 1943 showed little or no stimulation in gum yield. Other experiments, in which untreated streaks were put on at the end of the 1943 season, also showed the same response in the spring of 1944.

The results of an extreme in intensity of chemical treatment are summarized in table 11. In this experiment chemical treatments were started in April 1942, and continued without the usual winter rest period until August of the next year. During the regular chipping season a substantial yield increase of 63 percent was obtained. Continued treatment during the winter and the first portion of the next season showed an actual decrease in yields from the treated streaks. The effective treatment period for the first season for weekly acid treatment extended from April through September, with an average increase of 70 percent for this period. This is in contrast to only 63 percent when based on a normal season's results. From September 1942, through August 1943, none of the treated streaks gave significantly more gum than the untreated streaks. This illustrates the detrimental effect of the wrong use of an intensive chemical treatment.

Table 11. - Yield results for continuous chipping and treatment for a total of 70 streaks (April 1942 to August 1943) for slash pine

Period	First season 4/12 - 11/23/42		Winter season 11/23/42 - 4/12/43		Second season 4/12 - 8/16/43	
Chipping frequency and chemical treatment	Average yield in grams	Percent increase or decrease	Average yield in grams	Percent decrease	Average yield in grams	Percent decrease
Weekly						
Untreated	2847	--	1301	--	2153	--
40% H_2SO_4	4048	+63	1126	-13	2110	- 2
Biweekly						
Untreated	1374	-45	--	--	--	--
40% H_2SO_4	3026	+22	1150	-12	1688	-22
Delayed acid*	2201	-12	--	--	--	--

*Chipping every other week, with acid applied 1 week after chipping.

A treatment of moderate intensity, such as 20-percent sulphuric acid applied to weekly chipping, does not appreciably decrease in effectiveness from year to year (table 5). Another conservative treatment, given for only the last half of the first season, and illustrated by the 40-percent sulphuric acid skip treatment summarized in table 6, shows little or no decrease the second year in its stimulating effect. The increased yields during the effective treatment periods for this latter treatment were respectively 48 and 52 percent for the 1942 and 1943 seasons.

It is thus evident from all results to date that, in general, not only is the continued use of some chemical treatments beyond the effective treatment period economically unsound, but an actual decrease in yields can be expected in successive years of treatment, particularly when intensive acid treatments are used. To avoid this difficulty two alternatives are possible. First, intensive acid treatments can be stopped, but chipping continued, at the end of the effective treatment period. Second, less intensive acid treatments may be continued somewhat longer but in no event past the effective treatment period. Preliminary results consistently show that the addition of a minimum of about 4 or 6 untreated streaks after treatments stop in the fall will reduce or eliminate the first unproductive treated streaks put on the following spring. This procedure should invariably be applied to both the alternatives mentioned above.

Effect of Chemical Stimulants on the Trees

One question frequently raised by those interested in using chemical stimulants concerns the effect on the health and future productive capacity of the tree. An effective answer is provided in the fact that no tree in our experiments has ever been killed through chemical treatment, and most important, trees that are now in their fourth year of treatment are still producing more gum than those not treated.

A comprehensive study of the effects of chemical stimulants on trees has been underway since the initiation of intensive work early in 1942. The first report (41), dealing with resin soaking and crown appearance, was based in part on trees which are now in their fourth year of treatment. The authors found that "No serious injury resulting from chemical treatment has been noted either on trees in the controlled experiments at Olustee, Florida, or on trees in those commercial-scale tests in Georgia and Florida which were carefully examined." They also specifically state that ". . .(1) The red lightwood condition induced in acid-treated faces is not dry face, and does not develop into dry face although dry face may occasionally be found in such trees just as it is in untreated trees. (2) On the basis of crown appearance it seems to be impossible, after 3 full seasons of working, to distinguish acid-treated trees from trees that have been chipped without treatment."

Conclusions from the earliest work reported in Germany by Kublun (17) mentions that "No damage to trees was found after a full season's work." Hessenland (13) reports that in the 1935 experiments using over 8000 faces, "Damage to the trees has not been observed so far." In his 1938 report Loycke (24) states that Splitter in 1936 found that "The effectiveness of the stimulant is not diministed when the tree is treated for a number of years." No statements were made by Russian workers (in the available literature) as to the effect of chemical stimulants on the tree.

Results of portions of other experiments performed at this station indirectly support the conclusion that no serious permanent harm is done to the tree by chemical stimulants. One example is furnished by the preliminary multiple-cup experiments using as many as nine acid-treated faces per tree. In this instance enormous yields of gum were obtained from single trees over a portion of the season, amounting to many times the yields usually obtained from single trees in that period. In spite of this large drain on the tree's reserves, and the lack of any uninterrupted bark bars, these trees are still alive 1 year later although growing much slower. In another instance about four quarts of 40-percent sulphuric acid per tree were taken up during the season from shields placed around freshly cut streaks. Although considerably more gum was dipped from these trees than is usually obtained in one season, no harm was done to the trees from the standpoint of impairing further gum yields or causing any apparent injury. The use of concentrated sulphuric acid also appeared to result in no damage to the tree, although it necessitated the removal of more wood per streak after a period of treatment; this treatment is not recommended for use in any event.

This experience, combined with the abundant evidence obtained in previous experiments here and abroad, makes it possible to state conclusively that no apparent permanent injury to the tree results from the use of chemical stimulants to increase gum yields.

Effect of Chemicals on Gum and Its Constituents

Comparative tests on gum grades and relative amounts of turpentine and rosin were begun with the inception of the use of chemicals in stimulating yields, both in this country and in Europe. The consensus is summarized in a recent report (29): "From results of the tests made so far, there appears to be no reason for not using acid or caustic soda stimulation as far as rosin grades and yields of turpentine and rosin are concerned."

Early Russian and German workers made essentially the same statement, but qualified it by saying that when excessive quantities of the chemicals were present in the original gum samples, differences were noted in some of the physical properties and chemical constituents of the gum, and in the products of distillation. These findings have been well summarized by Hessenland (14) and Sandermann (33). They point out certain disadvantages obtaining for specific rosin uses when excess hydrochloric acid is present in the gum. According to these authors, however, these disadvantages are not evident when modern gum-cleaning processes are used during distillation procedures, or when care is originally taken to avoid excess acid in the gum. This latter can be done by care in treating with proper applicators such as well-controlled sprays; "painting" on the chemicals with brushes or swabs is not the best procedure because of the danger of excess acid in the gum caused by dripping. Also, greater yields were obtained with sprays (39).

Comprehensive studies of the effects of chemical stimulation on gum grades, and the yields of turpentine and rosin and their chemical and physical characteristics, were begun early in 1943 by the Naval Stores Division of the Bureau of Agricultural and Industrial Chemistry in cooperation with the Forest Service. A preliminary report (29) covers only a portion of this study, which is being continued in 1944. It was found that cloudy rosin is sometimes

obtained from gum from acid-treated trees when processed on a fire still. However, as Mitchell (25) points out, "According to present information rosin grades are unaffected by chemical stimulation if the gum from treated trees is either blended or properly cleaned in processing."

Large-Scale Tests of Chemical Stimulants

Shortly after the success of the initial 1933 experiments in Germany (12), trials were made on a much larger number of Scotch pines. Hessenland (13) mentioned a total of over 8500 trees in the 1935 tests, with considerable yield increases being obtained with 25-percent hydrochloric acid. The 1937 tests described by Loycke (24) included over 350,000 trees about equally divided between three separate areas. Yield increases for the three areas were 208, 265, and 250 percent. He concluded that "The results of earlier smaller-scale studies by Hessenland, Kublun, and Splitter apply equally well to other forest and climatic conditions, and on a large commercial scale."

Acid stimulation tests (3), conducted under the 1942 Naval Stores Conservation Program on about 72,000 trees on 17 different operations, showed yield results varying from a decrease of 9 percent to an increase of 38 percent. Investigations showed that the poorer results obtained on some acid test areas could almost always be traced to poor workmanship in regularity of chipping and adequacy of chemical treatment.

Dorman (5) reports that in 1943 a total of 13 out of 14 commercial operations keeping careful records on a total of approximately 90,000 trees obtained substantial yield increases by the use of chemical stimulants. There were nine operations that showed increased net profits from stands receiving chemical treatments. Frequent inspections and analysis of all factors concerned indicated that increased yields were directly correlated with the quality of workmanship, since sufficient quantities of the chemical adequately applied to regularly chipped streaks resulted in material increases.

The potential and actual profits to be derived from commercial operations have been discussed by Mitchell and Dorman (26). They summarize the results of the 1942 tests and present a comprehensive discussion of the economics of chemical stimulation.

Physiological and Anatomical Studies

Although European workers have studied the physiological processes involved in gum exudation (2, 15, 16, 28, 43), and the attendant increases in flow with chemical stimulation (1, 23, 30, 42), there is little agreement as to the exact chemical, physical, and anatomical conditions that exist. This confusion is probably natural in that relatively little basic physiological and anatomical work has been done on oleoresin formation, transport, and exudation alone, without the complications of chemical treatment. The work of Münch (28) is most widely quoted, but other workers have made equally important contributions. Space is not available here to summarize the work that has been done, but moderately comprehensive summaries are available (7, 35, 40). The simplest published explanation has been made by Hall et al (8, 9, 10) who briefly present a picture of some physiological factors concerned with oleoresin production. This is far from a complete resumé of the internal phases that are concerned, but serves as an introduction to the complicated pattern we have only glimpsed.

Most investigators are of the opinion that chemicals influence gum flow in pines by bringing about numerous synchronized physiological and anatomical changes. These changes involve, among other things: (1) increasing the effectiveness of the radial system of resin ducts; (2) keeping gum passages open for longer periods of time; (3) maintaining gum in a more fluid state by retarding crystallization internally; and (4) increases in metabolic level—the formation or synthesis of precursors and oleoresin itself.

Several valuable leads, from the standpoint of practical application, resulted from early fundamental studies of chemical stimulants in naval stores at this station. One of these, the effect on yields of deep gutter insertions using a broadax (36), was an outgrowth of studies designed to delimit the source of the extra gum obtained from chemical stimulation. Another, stemming from other portions of the same study, was the initial use of bark chipping on slash and longleaf pines (37). The synergic effect of added arsenic (38) and of phosphorous was first found in studies of the effects of various classes of chemical compounds on gum yields.

SUMMARY

This paper is devoted primarily to the presentation of the results of experimental work on chemical stimulation of gum flow performed in 1942 and 1943 on the Olustee Experimental Forest, Lake City, Fla., with major emphasis placed on those phases which were important as the basis for the 1943 and 1944 recommendations. No attempt is made to summarize all the work previously published, but pertinent papers and historical background are described briefly.

The following brief statements summarize the more important findings of the experimental work of 1942 and 1943:

1. Consistently greater yield increases have been obtained with sulphuric and hydrochloric acids than with any other single chemical used.

2. Still further yield increases have resulted from treatments with chemical combinations of sulphuric acid with such substances as sodium arsenite, potassium phosphate, and potassium aluminum sulphate.

3. After a consideration of all factors, the most effective concentration of sulphuric acid for treating slash pine was found to be 40 percent, with 60 percent the best for longleaf pine. Adequate chemical application was found to be almost as important as concentration, with yield increases up to 121 percent being obtained with careful treatment.

4. Greatest yields were obtained from weekly chipping with acid treatment. Under conditions of labor shortages necessitating less frequent chipping, however, greatest yields can be obtained by applying acid each time a tree is chipped. A skip treatment, in which weekly chipping is combined with acid treatment every other week, also showed considerable promise as a method to obtain increased gum yields.

5. The most outstanding result of the studies of the effects of different depths and heights of chipping combined with chemical treatment was the increased yields associated with bark chipping. It was found that taking off only the bark down to but not including the wood, and treating with acid, gave greater yields than acid applied to any streak cut into the wood.

6. Weekly yield records of treated and untreated trees indicated that after about 20 streaks the increased yields associated with the more intensive chemical treatments usually decline. Continued chipping without chemical treatment for the remainder of the year is economically sound and leaves the trees in better condition to respond to chemical treatments the following season.

7. All studies combined, both here and in Europe, indicated conclusively that no apparent permanent injury to the tree results from the use of chemical stimulants to increase gum yields.

8. There appears to be no reason for not using acid stimulation as far as rosin grades and yields of turpentine are concerned.

9. Large-scale tests made on more than 30 commercial operations showed that greatly augmented yields may be obtained under optimum conditions of chemical treatments, and that acid treatment is economically feasible.

10. Although many of the fundamental physiological and anatomical responses and conditions associated with chemical stimulation are known, no single adequate explanation covering all phases of the complex reactions can be formulated at this time.

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PULPWOOD- AND LOG-PRODUCTION COSTS IN 1945 AS COMPARED WITH 1940

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Southern Forest Experiment Station

U. S. DEPARTMENT OF AGRICULTURE
FOREST SERVICE

SOUTHERN FOREST EXPERIMENT STATION
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The Occasional Papers of the Southern Forest Experiment Station present information on current southern forestry problems under investigation at the Station. In some cases, these contributions were first presented as addresses to a limited group of people, and as "occasional papers" they can reach a much wider audience. In other cases, they are summaries of investigations prepared especially to give a report of the progress made in a particular field of research. In any case, the statements herein contained should be considered subject to correction or modification as further data are obtained.

PULPWOOD- AND LOG-PRODUCTION COSTS IN 1945 AS COMPARED WITH 1940

By R. R. Reynolds, Forest Economist
Southern Forest Experiment Station

The Southern Forest Experiment Station in 1940 made a study of pulpwood- and sawlog-production costs in the western part of the pine-hardwood region of the Lower South.1/

The war has significantly altered the costs observed in 1940. Labor efficiency has dropped. Wage rates have risen. Transportation costs have gone up because of the shortage of new trucks, high maintenance costs, poor tires, and the increased price of equipment and supplies such as trucks, tools, and feed. Supervision costs have risen with the change from contract to direct-employment operations.

In order to determine how far pulpwood- and log-production costs have risen since 1940, a study has been made to bring the old figures up to date and to draw a comparison between 1945 and 1940. It must be remembered that this comparison covers only part of the steps of production between the tree and the finished product. There are other elements of lumber-production cost, for example, that are not here considered. The data do not, therefore, show changes in total cost of finished products. It must be remembered, too, that the data apply only to dry-weather logging in the Crossett, Ark., area, though they are in such form that they can readily be revised to apply to other conditions and localities.

Type of Equipment Used

Some log and pulpwood contractors are now using power saws for felling and bucking; others are using tractors for bunching and loaders for loading. Most, however, are still using cross-cut and bow saws for felling and bucking and teams for both skidding and loading, just as they did in 1940. Since this is true and since it is desired to determine costs in 1945 as compared to 1940, the present study is based on the use of hand labor and teams.

There has been very little change since 1940 in the type or construction of trucks and trailers used in the hauling of either logs or pulpwood. Pulpwood costs given herein, therefore, are based on the use of regular 1-1/2-ton trucks with 85-horsepower motors and with dual wheels on the rear. Log costs are based on a standard truck and pole-trailer outfit with both the truck and trailer dual-wheeled. Tires used in 1945 are larger than in 1940 and are usually 7.50 x 20 on the front wheels and 8.25 x 20 on the rear and on the log trailer. In 1940 most tires used were 32 x 6 size.

1/ Reynolds, R. R. Pulpwood and log production costs as affected by type of road. Southern Forest Expt. Sta. Occasional Paper 96, 11 pp., tables. Oct. 14, 1940.

Cost of Log and Pulpwood Cutting

In 1945 the average daily production of 2-man felling and bucking crews is approximately 4,000 feet of logs (Doyle-Scribner rule) or 14 cords (approximately 3.5 standard cords) of pulpwood. In both cases this is less than in 1940; however, to earn a living wage, workers do not need to produce as much per day because of the higher wage rates now being paid. The comparative cost of cutting, per crew of two men per hour of operation, for the two periods is shown in table 1.

Table 1.--Estimated hourly cost of a felling and bucking crew of two men

Item	1940		1945	
	Dollars		Dollars	
A. Current operating costs:				
1. Direct labor costs: 1/				
Labor--2 men	.600		1.120	
Social security--employer 4%	.024		.045	
Total		.624		1.165
2. Other direct costs:				
Supplies--oil, wedges, etc.	.026		.033	
Maintenance	.004		.063	
Supervision	.043		.063	
Total		.073		.159
B. Ownership costs:				
1. Depreciation of saws, axes	.008		.010	
2. Interest, taxes, insurance	.001		.001	
Total		.009		.011
All costs		.706		.335

1/ Average production per 8-hour day:

	Logs	Pulpwood
1940	6,000 bd.ft. Doyle-Scribner	4.0 std. cords
1945	4,000 bd.ft. Doyle-Scribner	3.5 std. cords

Cost of Log Skidding and Loading

Log-skidding and -loading costs, also, have increased considerably, chiefly because of increases in wage rates and the cost of team feed. The skidding cost per unit of one team and driver in 1940 was $0.62; now it is $1.19. The breakdown of costs per hour of operation for each of the two periods is given in table 2.

Table 2.--Estimated hourly cost per crew of one team and driver skidding and loading logs

Item	1940		1945	
	Dollars		Dollars	
A. Current operating costs:				
1. Direct labor costs:				
Teamster	.300		.600	
Social security--employer 4%	.012		.024	
Total		.312		.624
2. Other direct costs:				
Feed	.187		.400	
Harness and equipment upkeep	.025		.050	
Supervision	.043		.063	
Total		.255		.513
B. Ownership costs:				
1. Depreciation of team	.041		.041	
2. Interest, taxes, etc.	.009		.009	
Total		.050		.050
All costs		.617		1.187

Cost of Operating Trucks and Trailers

Like woods costs, basic items of transportation cost have increased greatly. Trucks are more expensive; tires last about half as long; running expenses are about double those of 1940: and labor is more expensive. Comparison of truck costs per hour of operation or mile of distance is given in table 3 for trucks used on pulpwood production and table 4 for trucks and trailers used on log hauling.

Comparison of 1945 With 1940 Pulpwood- and Log-Production Costs

The total cost of producing logs and pulpwood in 1945 as compared with 1940 is given in table 5. These figures are based on the following output per 8-hour day per cutting crew of two men: in 1940, 4.005 standard cords of pulpwood or 6,000 feet (Doyle rule) of logs; in 1945, 3.5 cords of pulpwood or 4,000 feet of logs. The output per log-skidding and -hauling crew was assumed to be 5,600 feet Doyle rule per 8-hour day, the same as in 1940. The output of pulpwood per truck is also assumed to be the same in both periods. In 1940 the pulpwood-hauling crew was composed of the driver and an average of 1.63 helpers. In 1945 the driver and two helpers made up the crew. In the hauling of both logs and pulpwood the loading, unloading, and delay time are based on hourly rates. Hauling is based on the cost or running expense per mile of distance and changes with the type of road, which in turn affects speed and wear and tear. In table 5 it is assumed that the hauling of both logs and pulpwood will be over 1/2 mile of woods road, 1-1/2 miles of graded dirt road, and 5 miles of gravel road. For distances or types of road different from these the cost figures would, of course, have to be changed. The 1940 and 1945 production-cost figures are both based on net cost plus a 20-percent allowance for profit and risk.

Table 3.--Estimated costs per truck used for pulpwood hauling (1-1/2-ton, 85-horsepower truck)

Item	1940	1945
	Dollars	Dollars
Investment:		
Truck complete with cab and dual wheels	950.00	1,740.12
Minus tires[1]	-300.00	-567.48
Net investment	650.00	,172.64
Minus truck trade-in value	-200.00	-400.00
Total amount to be depreciated	450.00	772.64
Fixed Expenses:		
Interest on investment[2] at 6% per year	35.62	60.22
License and taxes per year	51.31	51.31
Operating overhead and risk per year	20.00	50.00
Total (per year)	106.93	161.53
Fixed expenses above, per day (225-day year)	.475	.718
Depreciation of truck per day (life=400 days)	1.500	1.932
Total (per day)	1.975	2.650
Fixed expenses above, per hour (10-hour day, truck only)	.198	.265
Driver and 2 helpers, cost per hour	.789	1.600
Supervision per unit per hour	.043	.063
Social security and insurance--4% of labor cost	.033	.067
All fixed expenses per hour	1.063	1.995
Running expenses per mile:		
Woods or low-quality road:		
Tires (life=4,000 miles in 1945)	.038	.142
Gasoline--5 miles per gallon	.040	.040
Oil and grease	.003	.003
Repair labor	.003	.010
Repair supplies	.003	.010
Total	.087	.205
Graded dirt or better-quality road:		
Tires (life=7,500 miles in 1945)	.020	.076
Gasoline--9 miles per gallon	.022	.022
Oil and grease	.003	.003
Repair labor	.003	.010
Repair supplies	.003	.010
Total	.051	.121

1/ Cost of tires charged against running expenses in 1945:
Front tires and tubes, 7.50 x 20, $89.74 each.
Rear tires and tubes, 8.25 x 20, $97.00 each.

2/ Average investment=$\frac{\text{initial investment+trade-in value}}{2}+\frac{\text{annual depreciation}}{2}=$

$$1945 = \frac{1,172.64 + 400.00}{2} + \frac{434.61}{2} = 1,003.62$$

Table 4.--Estimated costs per truck used for log hauling (1-1/2-ton, 85-horsepower truck with trailer)

Item	1940	1945
	Dollars	Dollars
Investment:		
Truck complete with cab and dual wheels	950.00	1,740.12
Trailer complete with dual wheels	450.00	603.43
Gross investment	1,400.00	2,343.55
Minus tires 1/	-500.00	955.48
Net investment	900.00	1,388.07
Minus trade-in value of truck and trailer	-300.00	-450.00
Total amount to be depreciated	600.00	938.07
Fixed Expenses:		
Interest on investment 2/ at 6% per year	47.81	68.54
License and taxes	51.31	51.31
Operating overhead and risk	20.00	50.00
Total (per year)	119.12	169.85
Fixed expenses above, per day (225-day year)	.529	.755
Depreciation of truck 3/ and trailer 4/ per day	1.750	2.208
Total (per day)	2.279	2.963
Fixed expenses per hour (10-hour day), truck and trailer only	.228	.296
Driver, cost per hour	.300	.600
Supervision per unit per hour	.043	.063
Social security and insurance--4% of labor cost	.014	.027
All fixed expenses per hour	.585	.986
Running expenses per mile:		
Woods or low-quality road:		
Tires (life=4,000 miles in 1945)	.062	.239
Gasoline--4 miles per gallon	.050	.050
Oil and grease	.003	.003
Repair labor	.003	.010
Repair supplies	.003	.010
Total	.121	.312
Graded dirt or better-quality road:		
Tires (life=7,500 miles in 1945)	.033	.127
Gasoline--8 miles per gallon	.025	.025
Oil and grease	.003	.003
Repair labor	.003	.010
Repair supplies	.003	.010
Total	.067	.175

1/ Cost of tires charged against expenses in 1945:
Front tires and tubes, 7.50 x 20, $89.74 each.
Rear and trailer, 8.25 x 20, $97.00 each.

2/ Average investment in 1945 = truck $1,003.62 (see table 3)
Trailer in 1945 = $\frac{165.43 + 50.00}{2} + \frac{62.10}{2} = 1,142.38$

3/ Life=400 days.

4/ Life=600 days.

Table 5.--Comparison of 1945 with 1940 pulpwood- and log-production costs 1/

Item	Cost in 1940	Cost in 1945	Cost increase	
	Dollars	Dollars	Dollars	Percent
Pulpwood:				
Felling and bucking 2/	1.69	3.69	2.00	118
Loading, unloading, delay 3/	.81	1.52	.71	88
Hauling 3/	.95	2.02	1.07	113
All costs	3.45	7.23	3.78	110
Logs:				
Felling and bucking	1.13	3.23	2.10	186
Skidding	.69	1.34	.65	94
Loading, unloading, delay 4/	.90	1.61	.71	79
Hauling 4/	1.24	2.87	1.63	131
All costs	3.96	9.05	5.09	129

1/ Computed at cost plus 20 percent for profit and risk.
2/ Per standard cord of penned wood.
3/ Per standard cord hauled over 1/2 mile of woods road, 1-1/2 miles of graded dirt road, and 5 miles of gravel road.
4/ Per thousand feet Doyle-Scribner rule for loads averaging 1,400 feet, hauled over 1/2 mile of woods road, 1-1/2 miles of graded dirt road, and 4 miles of gravel road.

Application of Data to Other Conditions

It is realized that cutting and hauling conditions, timber size, and the type of trucks and equipment vary from one locality to another. The information given for the Crossett area may not be applied to other areas without first checking on local conditions and making corrections where necessary. To adjust felling and bucking cost as given in table 5 to other conditions all that needs to be done is to compute new daily or hourly costs (table 1), add 20 percent for profit and risk, and divide by the production per day or per hour. If the output per day of felling and bucking crews is more or less than shown, divide the total cost per day as computed from table 1 by the new volume and add 20 percent for profit and risk. For changing skidding cost to some other rate or output per day the same adjustments should be made as in the case of felling and bucking.

The time required for "loading, unloading, and delay" was as follows:

Product	Time required per load for loading, unloading, and delay
	Hours
Pulpwood	1.26
Logs	1.07

Should the time required for loading, unloading, and delay be more or less than the above, increase or decrease the cost for this item in table 5 by the appropriate percentage.

The pulpwood-production costs of table 5 are based on loads averaging 1.98 standard cords. Should the loads in another locality average more or less than this, the cost of loading, unloading, and delay will need to be adjusted upward or downward. To do so, divide the total fixed cost per load (fixed cost per hour, table 3, times number of hours required per load) for pulpwood trucks by the number of cords carried, and increase the result by 20 percent. The same adjustments for loading, unloading, and delay would be necessary in the case of log hauling if the loads carried were greater or less than 1,400 feet Doyle-Scribner rule. In this case, however, it would be necessary to make an adjustment for the cost of the team and driver used in loading as well as for the truck used. To make this adjustment, multiply the loading time per load (.688 hour) by the team rate per hour (table 2). Also multiply the total time the truck was idle while loading, unloading, or delayed, by the truck fixed rate per hour (table 4). Add the two products and divide by the volume per load. The result should then be increased by 20 percent for profit and risk before being substituted in table 5.

Few loads of logs or pulpwood will be hauled over the same distance or the same type of roads as was assumed in this study. In nearly all cases it will, therefore, be necessary to revise the hauling costs reported in table 5. Since hauling cost is based partially on a cost rate dependent upon time required per trip and partially on a cost rate that is dependent upon the distance traveled and the type of road over which the hauling is done, the revision necessary to obtain corrected hauling cost in a particular case is as follows:

1. Determine the round-trip hauling time (exclusive of loading, unloading, and delay) required per load for the haul in question.

2. Multiply this time by the total fixed expense per hour shown in table 3 or 4, depending upon whether the product hauled is pulpwood or logs.

3. Determine the number of miles or fractions of a mile of ungraded woods or other low-quality road and of good graded dirt or higher-class road traversed in making a round trip. Multiply the number of miles of each type of road by the appropriate rate from table 3 or 4, or a similar revised table.

4. Add the fixed and the running expenses per load.

5. Divide the total cost per load by the average volume hauled to get the corrected hauling cost for the particular set of conditions under which the hauling is being done.

This completes the major adjustments of the rates given in table 5 to make them apply to other conditions. Other minor corrections sometimes may be necessary to obtain very accurate costs. For practical purposes, however, the major adjustments are all that need be considered to obtain good pulpwood- or log-production costs where equipment and methods are similar to those described.

OCCASIONAL PAPER NO. 108

July 1, 1946

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PUBLICATIONS OF THE SOUTHERN FOREST EXPERIMENT STATION

JULY 1921 - JUNE 1946

U. S. DEPARTMENT OF AGRICULTURE
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SOUTHERN FOREST EXPERIMENT STATION
Chas. A. Connaughton, Director
New Orleans, La.

PUBLICATIONS OF THE SOUTHERN FOREST EXPERIMENT STATION

JULY 1921 - JUNE 1946

This is a selected list of publications prepared by the personnel and collaborators of the Southern Forest Experiment Station since the Station was established in July 1921. A total of 931 titles are listed. Many of these have been printed or duplicated in quantity for distribution. Those still available for distribution are marked with an asterisk (*).

The publications are listed according to subject so as to make the compilation most usable to the wide variety of interests which will be concerned. Arrangement is by year and author within each subject. An index is attached in which title numbers are shown by authors.

It is not contemplated to reissue this compilation soon. It will be kept current, however, by addition of a supplemental listing each year of publications prepared during that period.

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OCCASIONAL PAPER 108 (REVISED) JANUARY 1955

PUBLICATIONS OF THE SOUTHERN FOREST EXPERIMENT STATION, JULY 1921 THROUGH DECEMBER 1954

SOUTHERN FOREST EXPERIMENT STATION
Philip A. Briegleb, Director
Forest Service, U. S. Department of Agriculture

OCCASIONAL PAPER 108

This edition of Occasional Paper 108 lists the publications issued by the Southern Forest Experiment Station and its collaborators from the establishment of the Station in 1921 through the close of 1954. It is intended as the final compilation for the period it covers. Publications subsequent to 1954 will be indexed in separate lists as need arises.

As the table of contents indicates, publications are classified under various subjects. Each title is recorded under one head only, but since many publications touch on several topics, users should consult all headings that appear related to their field of interest. An index of authors begins on page 124.

Publications marked with an asterisk (*) are available on request. The Station's address is 704 Lowich Building, New Orleans 13, Louisiana.

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39. Dense stands of reproduction and stunted individual seedlings of longleaf pine. W. G. Wahlenberg. 1934.

5/ The Occasional Paper series began with number 27. The preceding items, all of which are out of print, were unnumbered and not designated as Occasional Papers. The more important of them are classified under subject-matter heads earlier in this bibliography.

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1948 Supplement
Occasional Paper 108 March 15, 1948

PUBLICATIONS OF THE SOUTHERN FOREST EXPERIMENT STATION

In July 1946, a complete list of the publications of the Southern Forest Experiment Station was released as Occasional Paper 108. Since then the Station has issued over 100 publications, and this Supplement brings the original compilation up to date. Classification of the publications is the same as in the Occasional Paper.

Copies of publications marked with an asterisk (*) may be had free of charge on request to the Station.

SOUTHERN FOREST EXPERIMENT STATION
Chas. A. Connaughton, Director
1008 Federal Office Building
New Orleans, Louisiana

1. MANAGEMENT (INCLUDING SILVICULTURE AND FINANCIAL ASPECTS)

A. Southern pine and pine-hardwood types

*932. Bond, W. E. Forestry pays on the farm. South. Lumberman 173 (2177):127-130. Dec. 15, 1946.

932a. Brasington, J. J. Pull, cut, or poison? Forest Farmer 7(5): 14. Feb. 1948.

*933. Peevy, F. A. How to kill blackjack oaks with Ammate. South. Forest Expt. Sta. 3 pp. (Mimeographed.) Nov. 7, 1946. Revised Oct. 3, 1947.

*934. _____. Killing undesirable hardwoods. South. Lumberman 175(2201):123-125. Dec. 15, 1947.

935. _____, and Campbell, R. S. Poisoning undesirable hardwoods. Forest Farmer 6(7):6-7. April 1947.

"Unwanted hardwood trees successfully killed with poison." Naval Stores Rev. 57(27):7. Oct. 4, 1947.

*936. _____, and Campbell, R. S. Your customer: the forest farmer. South. Seedsman 11(3):16, 56. March 1948.

937. Stahelin, R. The conversion of hardwood to pine stands in Alabama. Jour. Ala. Acad. Sci. 18:58-59. May 1946.

B. Longleaf-slash pine type

(No publications.)

C. Loblolly-shortleaf pine-hardwood type

938. Abel, G. W. Suppression of hardwood on pine land. Miss. Farm Research 10(2):1, 8. Feb. 1947.

*939. Clark, S. F. Forest enemy number two. South. Lumberman 175(2201):182-184. Dec. 15, 1947.

940. Reynolds, R. R. Trees, a profitable crop. Natl. Farm Chemurgic Council. Chemurg. Papers No. 444, 6 pp. (Processed.) 1946.

*941. _____. Business opportunities in growing timber. Jour. Forestry 45(2):81-84. Feb. 1947.

Business opportunities in growing timber."Delivered before Farm Chemurgic Conference, Shreveport, La. 5 pp. (Mimeographed.) Nov. 5, 1946.

Forest farming in Arkansas. Ark. Outdoors 2(5):22 ff. May 1947.

Forest farming in Arkansas. Ark. Jr. Chamber of Com. 5 pp. (Mimeographed.) (N.d.)

*942. _____. 1946 cutting record, Farm Forestry Compartment 51--Crossett Experimental Forest. South. Forest Expt. Sta. 4 pp. (Mimeographed.) Jan. 1947.

*943. _____. Management of second-growth shortleaf-loblolly pine-hardwood stands. Jour. Forestry 45(3):181-187. March 1947.

Management of second-growth shortleaf-loblolly pine-hardwood stands. Prepared for management portion of Crossett Management Conferences. 8 pp. (Mimeographed.) Oct. 15, 1946.

*944. _____. Timber--a modern crop. Science in Farming (The Yearbook of Agriculture, 1943-47). Pp. 461-464. Washington, D. C. 1947.

*945. Reynolds, R. R. 1947 cutting record, Farm Forestry Compartment 51--Crossett Experimental Forest. South. Forest Expt. Sta. 4 pp. (Mimeographed.) Nov. 1947.

946. Smith, L. F. Early results of a liberation cutting in a pine-hardwood stand in northern Louisiana. Jour. Forestry 45(4):278-282. April 1947.

*947. Williston, H. L. Yours? Ten years from now. South. Lumberman 175(2201):187-189. Dec. 15, 1947.

*948. _____, and Rawls, I. W. Building up a poorly stocked farm forest. South. Forest Expt. Sta. Occas. Paper 110. 7 pp. (Processed.) Oct. 1947.

D. Bottomland hardwood type

(No publications.)

2. FIRE

*949. Bickford, C. A., and Newcomb, L. S. Prescribed burning in the Florida flatwoods. Fire Control Notes 8(1):17-23. Jan. 1947.

950. Bruce, D. Thirty-two years of annual burning in longleaf pine. Jour. Forestry 45(11):809-814. Nov. 1947.

*951. Wakeley, P. C., and Muntz, H. H. Effect of prescribed burning on height growth of longleaf pine. Jour. Forestry 45(7): 503-508. July 1947.

Prescribed burning pays. Naval Stores Rev. 57(30):11. Oct. 25, 1947.

3. PLANTING, SEED, AND NURSERY

*952. Arend, J. L. Growing eastern red cedar on the farm. South. Lumberman 173(2177):240, 242, 244. Dec. 15, 1946.

*953. _____. An early eastern red cedar plantation in Arkansas. Jour. Forestry 45(5):358-360. May 1947.

954. Maisenhelder, L. C. Fertilizer stimulates height growth of cottonwoods. Chilean Nitrate Ed. Bur., Inc., Farm for Victory No. 24, pp. 7-8. Oct. 1946.

*955. Muntz, H. H. Ice damage to pine plantations. South. Lumberman 175(2201):142-145. Dec. 15, 1947.

Mother nature says "no!" Naval Stores Rev. 57(48):13, 26. Feb. 28, 1948.

*956. Wakeley, P. C. Recent advances in storing, pretreating, and testing southern pine seed. U. S. Forest Service, Atlanta, Ga. 7 pp. (Mimeographed.) Jan. 7, 1946.

957. _____. Loblolly pine seed production. Jour. Forestry 45 (9):676-677. Sept. 1947.

958. Ware, L. M., and Stahelin, R. How far apart should pines be planted? South. Lumberman 173(2177):191-193. Dec. 15, 1946.

4. ECONOMICS AND TAXATION

959. Duerr, Wm. A. Review ["Farm Management," by John D. Black, Marion Clawson, Chas. R. Sayre, and Walter W. Wilcox. 1085 pp. 1947.] Jour. Forestry 46(1):57-58. Jan. 1948.

*960. James, L. M. The trend of lumber prices. Jour. Forestry 45 (9):646-649. Sept. 1947.

*961. Stover, W. S. Another look at southern forest industry problems. South. Lumberman 173(2177):202-205. Dec. 15, 1946.

5. RESOURCES

*962. Connaughton, C. A., and James, L. M. The forest resources of the South. Natl. Farm Chemurgic Council. Chemurgic Papers No. 550, 1947 Series No. 2, 9 pp. (Mimeographed.)(N.d.)

*963. Hutchison, S. B. Trouble spots: an audit of Dixie's forest assets. South. Lumber Jour. 51(6):24, 90. June 1947.

*964. Mesavage, C., and Duerr, Wm. A. Timber resources of the lower South, 1946. South. Pulp & Paper Jour. 9(9):58, 59, 64. Sept. 15, 1946.

"Timber resources of the lower South, 1946." South. Lumberman 172(2164):38-39. June 1, 1946.

6. HARVESTING, MANUFACTURING, MARKETING, UTILIZING, AND PRESERVING FOREST PRODUCTS

*965. Anderson, E. A. Kiln drying hardwoods green from the saw. South. Lumberman 173(2174):44. Nov. 1, 1946.

966. _____. Experiments with a unique pilot kiln. South. Lumberman 173(2177):272. Dec. 15, 1946.

967. _____. Paper strapping for baskets. Barrel & Box and Packages 52(2):11. Feb. 1947.

968. _____. Good and bad stacking practices. South. Lumberman series, 174(2179):63; 174(2181):73; 174(2183):80; 174(2185): 78. Jan. 15, Feb. 15, March 15, and April 15, 1947.

*969. Bond, W. E. More dollars from integrated utilization. South. Lumberman 175(2201):220-222. Dec. 15, 1947.

970. Carpenter, R. D. Organizing for efficient logging. South. Lumberman 175(2194):48 ff. Sept. 1, 1947.

"Pointers on logging efficiency given by R. D. Carpenter." South. Lumber Jour. 51(9):96, 97. Sept. 1947.

*971. Clark, S. F. Piggy-back loading of log trailers. South. Lumberman 173(2177):175-176. Dec. 15, 1946.

*972. Gregory, G. R. Marketing East Texas timber products. South. Forest Expt. Sta. 33 pp. (Processed.) July 1947.

*973. _____, and Person, H. L. Pine log grades and lumber recovery. South. Lumberman 173(2177):168-169. Dec. 15, 1946.

*974. Griswold, N. B., and McKnight, J. S. Wood use by Alabama mines. South. Forest Expt. Sta. Occas. Paper 109, 12 pp. (Processed.) Oct. 1947.

*975. _____, and McKnight, J. S. Alabama's mine-wood market. Ala. Conserv. 19(6):8-9, 14. Dec. 1947.

*976. Lehrbas, M. M. Recent developments in mills for sawing small logs. South. Lumberman 173(2177):212-214. Dec. 15, 1946.

*977. Lehrbas, M. M. Metal detector saving money for Mississippi lumber firm. South. Lumberman 175(2191):65, 68, 70. July 15, 1947.

Metal detector is saving money daily for Mississippi lumber firm following tests. Miss. Val. Lumberman 78 (28):6-7. July 11, 1947.

Mine detectors prove worth to Dixie sawmills. South. Lumber Jour. 51(8):90. Aug. 1947.

Mine detectors find saw log "booby traps." Wood 2(8): 23, 45. Aug. 1947.

Mine detectors for veneer mills. Veneers and Plywood 41(9):40-41. Sept. 1947.

Mine detectors used for locating metal in sawmill timber. Timber Topics 11(1):1, 4, 11. Jan.-Feb. 1948.

*978. _____. Fence post barking machines in the South. La. Forestry Comn. Bul. 3, 23 pp. (Processed.) Aug. 1947.

*978a. _____. Types of gas-fired kilns in the South. South. Lumberman 176(2207):101-102. Mar. 15, 1948.

979. Lockard, C. R. The future of wood. Logging and milling short course. Univ. Tenn., Knoxville, Tenn. 21 pp. (Mimeographed.) Feb. 1947.

*980. _____. Southern hardwoods for pulp and paper. Pulp & Paper Indus. 21(7):52 ff. June 1947.

*981. _____. Modernizing forest harvesting practices. South. Lumberman 174(2188):38. June 1, 1947.

982. _____. Foresters view timber harvesting machinery. South. Lumberman 174(2189):72 ff. June 15, 1947.

*983. _____. Cow food—a new forest product. South. Lumberman 175(2199):58, 60. Nov. 15, 1947.

Cow food from oak slab wood. Wood 2(12):35, Dec. 1947.

Molasses from hardwoods. Natl. Hardwood Mag. 21(12):26-27, 36. Jan. 1948.

*984. _____, and Carpenter, R. D. Interim sawlog grades for southern hardwoods. South. Forest Expt. Sta. 9 pp. (Processed.) Jan. 1947. Revised Jan. 1948.

985. Person, H. L. East Texas mill study shows low returns from small logs. Forest Farmer 6(4):7. Jan. 1947.

7. MEASUREMENTS (INCLUDING MEASUREMENT AND STATISTICAL TECHNIQUE, VOLUME AND YIELD TABLES, AND GROWTH)

986. Mesavage, C. Comment on "A simple method of volume table construction," by F. C. Reed. Jour. Forestry 44(3):197. March 1946.

*987. _____. New tables for estimating board-foot volume of timber. South. Lumberman 173(2177):153-156. Dec. 15, 1946.

*988. _____. Tables for estimating cubic-foot volume of timber. South. Forest Expt. Sta. Occas. Paper 111. 71 pp. (Processed.) Nov. 1947.

*989. _____. Board-foot volume tables for southern lumbermen. South. Lumberman 175(2201):195-197. Dec. 15, 1947.

*990. _____, and Girard, J. W. Tables for estimating board-foot volume of timber. 94 pp. Washington, D. C. 1946.

8. NAVAL STORES (INCLUDING ALL ASPECTS OF NAVAL STORES PRODUCTION)

991. Arend, J. L. Naval stores industry in post-war France. Naval Stores Rev. 57(48):14-15, 27, Feb. 28, 1948.

992. Skolnik, H., and Snow, A. G., Jr. Resin impregnation of catfaces; effect of new methods of turpentining upon the resin content of slash pine catfaces. Paper Trade Jour. 122(12): 52-53. March 21, 1946.

993. True, R. P. Some fungi are agents of dry face. The AT-FA Jour. 8(8):11-15, 20. May 1946.

"Dry face," Naval Stores Rev. 56(5):7-8, May 4, 1946; and Naval Stores Rev. 56(6):6-8, May 11, 1946.

9. BOTANY, ECOLOGY, AND SOILS

(No publications.)

10. WATERSHED MANAGEMENT (INCLUDING SOIL EROSION AND FLOOD CONTROL SURVEYS)

(No publications.)

11. GRAZING

994. Campbell, R. S. Determination of grazing values of native vegetation on southern pine forest ranges. Ecology 27: 195-204. July 1946.

*995. _____. Better grass for better beef; definite possibilities of increased production through better grazing on southern forest ranges. Amer. Hereford Jour. 37(5):288-290, 292. July 1, 1946.

996. _____. Timber and cattle. Forest Echoes 6(9):6-7, 14. Oct. 1946.

*997. _____, and Cassady, J. T. Bridging the gap: cattle can help the tree farmer. South. Lumber Jour. 51(3):19-20, 87. March 1947.

*998. Cassady, J. T. Feed, forage, and forests: The need for winter feed. Coastal Cattleman 13(8):7-8. Oct. 1947.

Range cattle need supplemental winter feed. Naval Stores Rev. 57(39):13-14, 28. Dec. 27, 1947.

*999. Hopkins, W. Pigs in the pines. Forest Farmer 7(1):3, 8. Oct. 1947.

Piney woods porkers turn bark into bacon. Naval Stores Rev. 57(48):16-17. Feb. 28, 1948.

*1000. _____. Piney woods hog hunt. Forest Farmer 7(2):3, 7. Nov. 1947.

*1001. _____. Hogs or logs? South. Lumberman 175(2201):151-153. Dec. 15, 1947.

Hogs or logs--longleaf pine seedlings and range hogs won't grow together. Naval Stores Rev. 57(43):12-13. Jan. 24, 1948.

*1002. Read, R. A. White-tailed deer--a forest crop in the Arkansas Ozarks. South. Lumberman 173(2177):141-142. Dec. 15, 1946.

12. DISEASES

*1003. Siggers, P. V. Fusiform rust: slash pine plantation threat. Miss. Farm Research 9(1):1, 7. Jan. 1946.

*1004. _____. Temperature requirements for germination of spores of Cronartium fusiforme. Phytopathology 37(12):855-864. Dec. 1947.

*1005. _____, and Lindgren, R. M. An old disease—a new problem. South. Lumberman 175(2201):172-175. Dec. 15, 1947.

1006. Verrall, A. F. Progress report on tests of soak and brush preservative treatments for use on wood off the ground. South. Lumberman 173(2168):36-38. Aug. 1, 1946.

Published in Agr. Engin. 27:367. 1946.

*1007. _____. Keep sapstain control dips up to strength. South. Lumberman 175(2198):36. Nov. 1, 1947.

"Keep sapstain dips up to strength." Timberman 49(1):74, 78. 1947.

13. INSECTS

(No publications.)

14. FOREST RESEARCH (METHODS, PROGRAMS, ACCOMPLISHMENTS, AND REPORTS)

1008. Burke, H. D. Research at Tallahatchie. Forest Farmer 6(7):3. April 1947.

1009. Cassady, J. T. Forest research at Alexandria. Forest Farmer 6(9):5, 7. June 1947.

1010. Connaughton, C. A. A current responsibility of foresters. The Annual Ring, La. State Univ., Baton Rouge, La. May 1946.

*1011. _____. Southern Forest Experiment Station marks its twenty-fifth anniversary. South. Lumberman 173(2177):179-182. Dec. 15, 1946.

1012. Duerr, Wm. A. Research in the economics of forestry. Ames Forester, pp. 11-23. Iowa State College, Ames, Iowa. 1947.

1013. Gaines, E. M. Brewton Branch serves longleaf pine type. Forest Farmer 6(8):4. May 1947.

1014. Grano, C. X. They come to Crossett. Forest Farmer 7(5):6. Feb. 1948.

1015. Griswold, N. B. Birmingham forest research center. Forest Farmer 6(5):6, 14. Feb. 1947,

1016. Maisenhelder, L. C. Delta research center studies hardwoods. Forest Farmer 6(2):4. Nov. 1946.

1017. Maki, T. E. The Gulfcoast research center. Forest Farmer 5(10):4, 7. July 1946.

1018. Ostrom, C. E. The Lake City forest research center. Forest Farmer 5(7):1, 3, 8. April 1946.

1019. Person, H. L. The East Texas forest research center. Forest Farmer 5(8):4-5. May 1946.

1020. Reynolds, R. R. Crossett--one of the oldest research centers. Forest Farmer 6(1):4, 7. Oct. 1946.

1021. _____. Guide to the research work on the Crossett Experimental Forest. South. Forest Expt. Sta. 23 pp. (Mimeographed.) Feb. 1947.

1022. Wheeler, P. R. Previewing research work in the Ozarks. Forest Farmer 6(3):6-7. Dec. 1946.

15. MISCELLANEOUS

*1023. Southern Forest Experiment Station. Publications of the Southern Forest Experiment Station, July 1921-June 1946. Occas. Paper 108. 58 pp. July 1, 1946.

1024. _____. Twenty-sixth annual report. 68 pp. 1946.

1025. _____. Twenty-seventh annual report. 90 pp. 1947.

16. SOUTHERN FORESTRY NOTES

*1026. No. 47, January 1947.
Advances in storing southern pine seed. P. C. Wakeley.
Barking fence posts by machine. M. M. Lehrbas.
Forest farming: 9th annual cut on the Crossett Forty. R. R. Reynolds.
Poisoning blackjack oaks with Ammate. F. A. Peevy.

*1027. No. 48. March 1947.
Grazing cattle in pine plantations. R. S. Campbell and J. T. Cassady.
The new southern Forest Survey. Wm. A. Duerr.
A nursery for cottonwood cuttings. L. C. Maisenhelder.
Southern hardwood sawlog grades. C. R. Lockard.

*1028. No. 49. May 1947.
Abbreviated "stratification." P. C. Wakeley.
Prescribed burning of longleaf plantations. H. H. Muntz.
Rotary-cut water oak veneer. E. A. Anderson.
Tree size holds up under selective cuts. R. R. Reynolds.

*1029. No. 50. July 1947.
Mine detector spots metal in sawlogs. M. M. Lehrbas.
Perhaps the hog is hungry. W. Hopkins.
Releasing pine from hardwood competition. S. F. Clark.
Wood use in Alabama mines. N. B. Griswold.

*1030. No. 51. September 1947.
Building up an understocked farm forest. H. L. Williston and I. W. Rawls.
The 1947 cone crop and forest fires. P. C. Wakeley.
Cows like wood molasses. C. R. Lockard.
Yields from 3 spacings of planted slash pine. H. Bull.

*1031. No. 52. November 1947.
Costs and realization values in producing pulpwood. W. E. Bond.
Fence posts from bottomland hardwoods. J. A. Putnam.
Sheep damage to longleaf pine seedlings. W. F. Mann, Jr.
Timber is an annual crop. R. R. Reynolds.

*1032. No. 53. January 1948.
Close spacing reduces fusiform rust. H. H. Muntz.
Close spacing reduces fusiform rust. W. F. Mann, Jr., and N. M. Scarbrough.
Cubic-foot volume tables. C. Mesavage.
Seeding and fertilizing forest range. F. A. Peevy, and R. S. Campbell.

*1033. No. 54. March 1948.
Keep lateral roots on longleaf planting stock. H. J. Derr.
Keep small trees growing. R. R. Reynolds and S. F. Clark.
Loblolly seedling survival in forest openings. W. G. Wahlenberg.
1946 pulpwood production. W. S. Stover.

OCCASIONAL PAPER 108 (SUPPLEMENT I) 1962

PUBLICATIONS OF THE SOUTHERN FOREST EXPERIMENT STATION, 1955 THROUGH 1961

Louis E. Punch

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Philip A. Briegleb, Director
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Compiled by

Louis E. Punch

Southern Forest Experiment Station

INTRODUCTION

This list supplements the 1955 revision of Occasional Paper 108, which cataloged the publications of the Southern Forest Experiment Station from 1921, when it was established, through 1954. Together, the two lists form a complete record of the Station's publications. Each is intended as the final compilation for the period it covers. Publications subsequent to 1961 will be recorded in future supplements.

The subject-matter classification is similar to that employed in 1955. Chief differences are that the headings **Range** and **Wildlife** have replaced **Grazing**, and that **Watershed** has been substituted for **Water**. Each title is recorded under only one heading. Since many publications touch on several topics, readers should consult all headings that appear related to their field of interest. The explanatory notes in the table of contents suggest some main lines of cross reference, and the index of authors may also be helpful in this respect.

Entries are accompanied by brief abstracts. Where two or more publications contain virtually the same information, the abstracts refer to the most comprehensive one, which generally will also be the most readily available. An asterisk (*) preceding an entry indicates that reprints or copies are available on request; the Station's address is Federal Building, 701 Loyola Avenue, New Orleans 12, La.

A few items that were overlooked in 1955 are recorded now.

MANAGEMENT OF ESTABLISHED STANDS

GENERAL

BRIEGLEB, P. A.
1956. SOUTH'S TIMBER CROP COULD BE DOUBLED. Banking 48 (11): 87.
"In the South . . . opportunities for increasing forest growth in response to mounting demand are outstanding, but it will take a lot of work to capture this promise. Bankers are in a good position to continue to take an important part in the jobs ahead."

* MAPLE, W. R.
1957. REDCEDAR GROWTH IN ARKANSAS OZARKS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 112.
Improvement cutting and hardwood control stimulated an eastern redcedar stand of 161 cubic feet per acre to grow to 214 cubic feet in 3 years, an increase of 10 percent annually.

* WILLISTON, H. L.
1959. NORTH MISSISSIPPI'S BLUE-RIBBON BALD-CYPRESS STAND. South. Lumberman 199(2489): 144-145, illus.
The stand seeded in between 1875 and 1890 on a moist site. Before a recent thinning it averaged 52,000 board feet per acre. Form class is about 80.

PINE-HARDWOOD

* BEAUFAIT, W. R.
1957. PINE OUTGROWS SWEETGUM IN UPLANDS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 109.
On a dry upland site in south Mississippi, loblolly pines of pulpwood size were found to be growing half again as fast in volume as sweetgums.

* BURTON, J. D.
1960. VIRGINIA PINE GROWTH POTENTIAL ON THE CUMBERLAND PLATEAU. South. Lumberman 200(2501): 44.
When clearcut at age 72 years, a stand on poor soil contained 25 MBF (International rule), plus 15 cords in tops and small stems. The average acre supported 233 stems, with a basal area of 152 square feet.

* CROKER, T. C., JR.
1955-61. ANNUAL CUTTING RECORDS, ESCAMBIA FARM FORESTRY FORTY. U. S. Forest Serv. South. Forest Expt. Sta. 4 pp. each.
Volume and value of timber harvested, in eighth through fourteenth annual cuts, on a 40-acre tract of longleaf and slash pine in southern Alabama.

* DAVIS, V. B.
1955. DON'T KEEP LONGLEAF SEED TREES TOO LONG! U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 98.
Longleaf pine seed trees not only keep their offspring small and vulnerable to fire, but their fallen needles increase the fuel supply.

* DERR, H. J., and ENGHARDT, HANS.
1957. SOME FORESTRY LESSONS FROM HURRICANE AUDREY. South. Lumberman 195(2441): 142-144, illus.
Slash pine was hit harder than loblolly or longleaf, chiefly because it has been widely planted on poorly drained flatwood sites, where a high degree of windfirmness cannot be expected. Much of the loss was in windthrow of dominant and codominant trees. Stands below merchantable size were damaged mainly by breakage of fusiform-infected stems. Dense stands were harmed less than some that had recently been heavily thinned.

* ENGHARDT, HANS.
1960. THINNING PLANTED LOBLOLLY PINE. Forests and People 10(2): 36, 43, illus.
A plantation in central Louisiana was thinned to various densities at ages 20, 25, and 30 years. Stocking of 90 to 100 square feet of basal area per acre produced the most cordwood or sawtimber. For very close spacings, such as 4 by 4 feet, stocking of 80 to 90 square feet appears best when high cubic-volume growth is the goal.

* GIBBS, C. B.
1958. MANAGING A SMALL FOREST IN EAST TEXAS. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 163, 7 pp., illus.
Ten years of management have transformed a wild woodland into a profitable forest. Costs averaged 95¢ per acre annually and net cash returns $3.20.

* GRANO, C. X.
1956. GROWING LOBLOLLY AND SHORTLEAF PINES IN THE MID-SOUTH. U. S. Dept. Agr. Farmers' Bul. 2102, 25 pp., illus.
Even heavily cut stands can be rapidly brought back into production. The first pages show the forest owner how to size up his woodland and diagnose its needs. Later sections give recommendations on protection, control of unwanted trees, thinning and pruning, and harvesting and marketing.

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1957. GROWTH OF LOBLOLLY PINE SEED TREES IN RELATION TO CROWN DENSITY. Jour. Forestry 55: 852.
Seed-trees with dense crowns make faster diameter growth than those with less foliage, but height growth and crown expansion tend to be independent of crown density.

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1961. DOES PRUNING PAY OFF? Forest Farmer 20(12): 10-11, illus.
A study with pine in south Arkansas indicates that, if pruning is to be worth the expense, it should be restricted to the fastest growing trees and those most likely to be carried to maturity, should begin when the trees are 3 to 5 inches in diameter, and should be followed by thinnings that are frequent and heavy enough to promote diameter growth of 3 inches per decade.

* GUTTENBERG, SAM.
1956. LOBLOLLY GROWS DESPITE DROUGHT AND BEETLES. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 103.
Net growth rate ranged from 5 to 9 percent.

KOSHI, P. T.
1956. THE WATER RELATIONS OF TREES. Paper read at "Water for Texas" Conf., Tex. A and M Col., 6 pp.
Some of the rain that falls on the forests of east Texas could be made available for irrigation or

industrial use, but at a high price in erosion and sedimentation. "Considering that east Texas pine lands earn something like $10 per acre per year at their natural job of growing pine trees, I think our objective should be to use in place just as much of the rain that falls on them as possible."

* McCLURKIN, D. C.
1958. SOIL MOISTURE CONTENT AND SHORTLEAF PINE RADIAL GROWTH IN NORTH MISSISSIPPI. Forest Sci. 4: 232-238, illus.
In 19-year-old plantations on loessial soils, strong interrelations were found between radial growth and elapsed days of the growing season, available soil moisture, soil temperatures, and interactions of these variables.

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1961. SOIL MOISTURE TRENDS FOLLOWING THINNING IN SHORTLEAF PINE. Soil Sci. Soc. Amer. Proc. 25: 135-138, illus.
Thinning 19-year-old plantations in north Mississippi increased soil moisture during middle and late summer, and thus speeded growth and extended the growing period. Diameter growth slackened when depletion was rapid.

MANN, W. F., JR.
1955. PRUNING RAISES PINE PROFITS. Prog. Farmer (Miss.-Ark.-La. ed.) 70(1): 24-25, illus.
Suggestions for pruning southern pines.

* MAPLE, W. R., and MESAVAGE, CLEMENT.
1958. REMARKABLE SHORTLEAF PINE STAND. Jour. Forestry 56: 290-291, illus.
At age 90, this stand contains 34 MBM (Int. rule) per acre. Mean annual growth rate, including some salvaged mortality, has been 425 board feet per acre. The average tree is about 13 inches d.b.h.; excessive stocking has reduced diameter growth and contributed to heavy mortality.

* _____ and SMITH, W. S.
1959. MANAGEMENT OF SMALL WOODLAND TRACTS IN THE ARKANSAS OZARKS. U. S. Forest Serv. South. Forest Expt. Sta., 4 pp.
Five small tracts in Newton County were placed under management in 1953. Though understocked, they have grown at rates of 3.7 to 8.0 percent annually.

MIGNERY, A. L.
1955. SEVENTH ANNUAL FOREST FIELD DAY, STEPHEN F. AUSTIN EXPERIMENTAL FOREST, NACOGDOCHES, TEXAS. U. S. Forest Serv. South. Forest Expt. Sta., 6 pp.
Products with a stumpage value of nearly $2,000 have been cut since 1947 from a 67-acre area managed like a farm forest.

MOYLE, R. C.
1955. "SHOULD I SELL THIS POLE?" READ THIS BEFORE YOU DO! Forest Farmer 15(2): 11, illus.
A reminder that pole trees increase in value as they improve in length and top diameter.

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1956. LEAPING LOBLOLLY. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 105. *Also in* South. Lumberman 193(2417): 186.
In a 62-year-old stand on a good site, growth has been 2.2 cords per acre annually on a plot kept thinned to 120 square feet of basal area per acre, 2.1 on a plot thinned to 110 square feet, and 1.5 on unthinned trees.

* MUNTZ, H. H.
1955-57. ANNUAL CUTTING RECORDS, BIRMINGHAM FARM FORESTRY FORTY. U. S. Forest Serv. South. Forest Expt. Sta., 4 pp. each.
Volume and value of timber harvested, in eighth through tenth annual cuts, on a 40-acre tract of pine and hardwood in north-central Alabama.

* REYNOLDS, R. R.
1955. MANAGED GROWTH. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 142, 16 pp., illus.
Results of the first 15 years of management on a 958-acre tract of loblolly and shortleaf pine on the Crossett Experimental Forest, in southern Arkansas.

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1955. PINE GROWTH UNDER MANAGEMENT. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 100.
See preceding entry.

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1956. MANAGEMENT OF PINE-HARDWOOD STANDS IN SOUTH ARKANSAS. La. State Univ. Fifth Ann. Forestry Symposium Proc. 1956: 39-46.
Review of work on the Crossett Experimental Forest shows that "so far we have only barely touched on the outer edges of the possibilities of increased timber production to be had through research and good management."

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1957. INTENSIVE TIMBER MANAGEMENT CAN BE PROFITABLE IN THE SOUTH. Soc. Amer. Foresters Proc. 1956: 119-121.
"Studies indicate that a yield of 500 board feet per acre per year can easily be had from all-aged pine stands with a good distribution of size classes (sites equal to 80 or better)."

* _____
1958. DROUGHT CAN BE COSTLY TO TIMBER-LAND OWNERS. South. Lumberman 196(2447): 32-33, illus.
The drought of 1952-1955 cost pine timber owners in southern Arkansas and northern Louisiana something like 16 million dollars yearly in lost growth. As dry years are more numerous than years of normal rainfall, stand improvement measures that will reduce competition for water should pay dividends.

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1958. PROFITS FROM GROWING LARGER TREES. AT-FA Jour. 20(12): 6.
Forest owners often miss high profits by cutting trees as soon as they reach minimum sawtimber size.

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1959. EIGHTEEN YEARS OF SELECTION TIMBER MANAGEMENT ON THE CROSSETT EXPERIMENTAL FOREST. U. S. Dept. Agr. Tech. Bul. 1206, 68 pp., illus.
Costs, returns, and silvicultural observations from a 958-acre understocked forest of second-growth pine and hardwood. Original stocking of pine averaged 4,669 board feet per acre. Though selection cuts removed nine-tenths of this volume, annual pine growth per acre has averaged 405 board feet for sawtimber-size trees and 74 cubic feet for all pines 4 inches and larger in d.b.h.

* _____ and RAWLS, I. W.
1955-61. ANNUAL CUTTING RECORDS, CROSSETT FARM FORESTRY FORTIES, CROSSETT EXPERIMENTAL FOREST. U. S. Forest Serv. South. Forest Expt. Sta., 4 pp. each.
Eighteenth through twenty-fourth annual harvests from the Good Forty, and seventeenth through twenty-third from the Poor Forty.

* RUSSELL, T. E., and DERR, H. J.
1956. LONGLEAF HEIGHT UNAFFECTED BY STAND DENSITY. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 101. *Also in* The Unit, News Letter 62, p. 6.
At age 20 years, pines in a plantation averaging 404 trees per acre were as tall as those in lighter stands.

* SIEGEL, W. C.
1961. LOBLOLLY PLANTERS THIN EARLY. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 135. *Also in* Amer. Tree Farmer and Forestry Digest, Jan.-Feb. 1962, p. 8. *Also in* Forest Farmer 21(12): 24. 1962.
Eight out of ten plantations in the region around Shreveport are thinned by age 15 years. By age 18, virtually all have been thinned once and half of them twice.

* SMITH, L. F.
1955. DEVELOPMENT OF SECOND-GROWTH LONGLEAF PINE IN SOUTH MISSISSIPPI. Jour. Forestry 53: 648-649, illus.
Observations on some of the oldest longleaf plots in existence show that second-growth stands can produce a cord of wood per acre annually.

* ———
1956. EARLY RETURNS FROM A SLASH PINE PLANTATION. South. Lumberman 193(2417): 212-213, illus.
Though it suffered heavy early mortality and was also damaged by fusiform rust, a slash pine plantation in south Mississippi has grown more than 1 cord per acre annually since its establishment in 1941. Some portions of it have grown more than 3 cords per acre annually.

* STEPHENSON, G. K.
1956. MORTALITY IN THE WOODPILE. South. Lumberman 193 (2417): 220-221, illus.
The droughts of recent years have greatly increased pine mortality in east Texas. Landowners are becoming interested in methods of salvaging the losses.

STERNITZKE, H. S.
1957. AUDREY'S TIMBER TOLL. Forests and People 7(4): 51.
In the Louisiana parishes that suffered the main damage, Hurricane Audrey broke and uprooted a total of 425,000 cords of pine and hardwood growing stock. This figure includes 85 million board feet in sawtimber trees. Hardwoods suffered 8 times as much damage as pines.

* WILLISTON, H. L.
1957. POLE GROWER'S GUIDE. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 153, 34 pp., illus.
Silvicultural considerations facing landowners who contemplate producing poles, and a compilation of volume tables, specifications, and references.

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1958. COST OF PRUNING LOBLOLLY AND SHORTLEAF. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 114.
See next entry.

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1959. COST OF PRUNING LOBLOLLY AND SHORTLEAF PINE. South. Lumberman 198(2470): 43.
In north Mississippi, 17-year-old loblolly pines were pruned to a height of 17 feet for 11 cents per tree; 23-year-old shortleaf cost 7 cents apiece to prune, chiefly because they had fewer and smaller limbs.

* YOCOM, H. A.
1960. DROUGHT SLOWS TIMBER GROWTH. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 125.
Growth in a pine-hardwood forest near Birmingham, Alabama, was reduced at least half by the drought of 1952-1956.

* ZAHNER, ROBERT.
1955. PLANTATION EXHAUSTS SOIL WATER RAPIDLY. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 95.
During June 1954, a young loblolly pine plantation in south Arkansas removed water from the ground at twice the rate that normal rainfall would have replenished it.

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1955. SOIL WATER DEPLETION BY PINE AND HARDWOOD STANDS DURING A DRY SEASON. Forest Sci. 1: 258-264, illus.
In southeastern Arkansas, soils of two well-forested areas of different species, but similar in climate, stocking, and site, were depleted of water at approximately the same rate.

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1956. EVALUATING SUMMER WATER DEFICIENCIES. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 150, 18 pp., illus.
Thornthwaite's concept of potential evapo-transpiration, combined with an understanding of water needs and supplies, can be used to estimate water deficiencies suffered by trees. This paper presents background material and data for evaluations on upland pine-hardwood forests of the Midsouth.

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1956. ROOT DEVELOPMENT OF THINNED PINES. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 101.
Roots and crowns expanded with equal vigor after a young loblolly pine plantation was heavily thinned.

* ———
1956. TAKES WATER TO MAKE WOOD. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 104. *Also in* The Unit, News Letter 65, p. 9.
In the Midsouth, about 750,000 gallons of soil water are needed to grow a cord of pine pulpwood.

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1956. THE TIMBER GROWER'S STAKE IN WATER. Forest Farmer 16(2): 9, 34, illus.
In the South, water supplies rarely are adequate for optimum forest growth throughout any growing season. Conserving the moisture stored in the soil—by timely thinnings and removal of cull trees and undesirable brush—has the same effect as additional rain.

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1958. HARDWOOD UNDERSTORY DEPLETES SOIL WATER IN PINE STANDS. Forest Sci. 4: 178-184, illus.
Depletion by well-stocked, even-aged stands of shortleaf and loblolly pine with and without hardwood understories was measured through four summers in south Arkansas. Midsummer water loss was about 25 percent faster on plots with an understory.

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1958. SEPTEMBER RAINS BRING PINE GROWTH GAINS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 113.
In southern Arkansas, 30 percent of the 1957 growth of a loblolly pine stand followed soil-moisture recharge by unusual September rains.

* ———
1959. CONTROLLED SOIL-MOISTURE EXPERIMENTS IN FOREST TREE-WATER RELATIONS First North Amer. Forest Soils Conf. Proc., pp. 12-19, illus. Michigan State Univ.
Field techniques—irrigation, crown and root pruning, shelters, and large containers—to help regulate soil moisture available to individual trees too large to be kept in a conventional greenhouse.

* ———— and WHITMORE, F. W.
1960. EARLY GROWTH OF RADICALLY THINNED LOBLOLLY PINE. Jour. Forestry 58: 628-634, illus.
A plantation in south Arkansas was thinned in 1954, when the trees were 9 years old. Where all but 100 crop trees per acre were removed, diameter growth was 4.3 inches in 5 years. Controls grew 1.9 inches when thinned to 85 square feet of basal area at 3-year intervals. The heavily thinned trees made diameter growth into late fall each year, while the controls ceased by midsummer, when they had depleted soil moisture. Height growth was not stimulated.

HARDWOODS

* BEAUFAIT, W. R., and JOHNSON, R. L.
1956. TIMBER BETTER AS RESULT OF WORK OF 15 YEARS AGO. Miss. Farm Res. 19(11): 1-2, illus. *Also as* Miss. Agr. Expt. Sta. Inform. Sheet 547, 2 pp., illus.
An improvement cut in 1940 markedly helped the growth and quality of a depleted stand of bottomland hardwoods.

* BRIEGLEB, P. A., and MCKNIGHT, J. S.
1960. THE PLACE OF HARDWOODS IN FOREST MANAGEMENT. The Unit, News Letter 83, pp. 10-11.
More than a third of southern forest land will probably yield its greatest multiple benefits if devoted permanently to the production of hardwoods.

BROADFOOT, W. M.
1958. A METHOD OF MEASURING WATER USE BY FORESTS ON SLOWLY PERMEABLE SOILS. Jour. Forestry 56: 351.
Water was impounded in winter on an area of Sharkey clay supporting a well-stocked hardwood forest. The daily drop in lake level was measured during spring and summer and designated evapotranspiration. Evaporation loss, as measured from a pan anchored in the lake, was then subtracted. The difference was the water used by the forest, as seepage through the Sharkey clay was deemed negligible.

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1958. STUDY EFFECTS OF IMPOUNDED WATER ON TREES. Miss. Farm Res. 21(6): 1-2, illus. *Also as* Miss. Agr. Expt. Sta. Inform. Sheet 595, 2 pp., illus. *Also in* Miss. Game and Fish 21(12): 6, 10, illus.
In fall and early winter, many landowners build temporary lakes in hardwood forests, usually to attract migrating waterfowl. Study of 16 such shallow impoundments in Arkansas and Mississippi showed that they increase the amount of water going into soil storage, and thus may benefit trees during a dry summer. The water must be released each spring, before tree growth begins. Continuous impoundment kills some species in one or two years, and all trees in four years.

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1960. SOIL-WATER SHORTAGES AND A MEANS OF ALLEVIATING RESULTING INFLUENCES ON SOUTHERN HARDWOODS. *In* South. Forest Soils. La. State Univ. Eighth Ann. Forestry Symposium Proc. 1959: 115-119.
See preceding entry.

GRANO, C. X.
1957. PRUNING-WOUND CLOSURE ON SOUTHERN RED OAK. Jour. Forestry 55: 669.
Five years after some southern red oaks were pruned, 85 percent of the wounds had healed over completely. Originally the wounds averaged 1.2 inches in diameter, ranging from 0.4 to 3.6 inches. They did not serve as an important entrance for rot.

* JOHNSON, R. L.
1958. BLUFF HILLS—IDEAL FOR HARDWOOD TIMBER PRODUCTION. South. Lumberman 197(2465): 126-128, illus.
Suggestions for improving forests in the loessial bluffs that lie east of the Mississippi River. The Southern Forest Experiment Station has established the Bluff Experimental Forest to conduct intensive research on the management of these sites—which are potentially among the Nation's best sources of prime hardwoods.

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1959. PRUNING COTTONWOOD. South. Lumberman 198(2473): 28-29, illus.
Preliminary studies in the Mississippi Delta suggest that pruning should not reduce the live crown to less than half the total height of the tree. Most wounds made by the pruning of branches 2½ inches in diameter (at a point 2 inches from the bole) healed in two growing seasons.

* ————
1961. PRUNING COTTONWOOD AND WILLOW OAK. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 136.
Cottonwood branches up to 3 inches in diameter may be pruned without serious danger from rot, insects, or epicormic branching. Willow oaks are prone to branch, some individuals more than others.

KOSHI, P. T.
1957. DIAMETER GROWTH OF POST OAK BEST IN SPARSE STANDS. Jour. Forestry 55: 847.
Post oak stands in Robertson County, Texas, were thinned from 65 square feet of basal area per acre to 39, 26, and 13 square feet. " . . . In this dry area, where growth is slow at best, the trees were able to benefit from thinning to exceptionally sparse densities."

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1959. SOIL-MOISTURE TRENDS UNDER VARYING DENSITIES OF OAK OVERSTORY. U. S Forest Serv. South. Forest Expt. Sta. Occas. Paper 167, 12 pp., illus.
The trees were post oaks, on Susquehanna-like soils in Texas. Either grass or trees were capable of withdrawing all available moisture from the upper 24 inches of soil. Trees drew from the upper and lower horizons simultaneously, while grasses tended to exhaust the upper horizons first. Thinning and clearing of the oaks reduced the number and duration of periods of moisture stress.

MCKNIGHT, J. S.
1956. THINNING OUR YOUNG GUM. Forests and People 6(3): 28-29, illus.
In recent years the demand for sweetgum pulpwood has made it feasible for landowners to thin their young gum stands commercially. Studies of thinning intensities have been installed, but until they yield results the best advice is to leave about 70 square feet of basal area per acre.

* ————
1957. BLACK WILLOW—HINTS FOR MANAGEMENT. Forests and People 7(3): 30-31, 50, illus.
Pending further study, light thinning, removing about ¼ of the volume of the stand, appears the safest initial cut in dense stands on the wettest river sites. In subsequent cuts, or on sites dry enough for the trees to be reasonably windfirm, removal of nearly half the volume may give best growth and least mortality. The poorest trees should be cut first.

* McKnight, J. S.
1958. THINNING STANDS OF WATER OAKS. La. State Univ. Seventh Ann. Forestry Symposium Proc. 1958: 46-50.
Water oaks produce best timber when grown in dense, nearly even-aged stands. Improvement cutting and thinning for release promote rapid growth, but tend to stimulate epicormic branching on suppressed and intermediate trees. This limbiness is not a serious problem on vigorous dominant and co-dominant trees.

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1959. BRIGHT FUTURE FOR HARDWOODS. Miss. Farmer 7(5): 10-11, illus.
Possibilities and elementary principles of managing southern hardwoods.

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1959. PROTECT AND MANAGE GOOD SOUTHERN HARDWOODS. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 169, 12 pp., illus. Other editions published in cooperation with Ala. Dept. Conserv., Div. Forestry; Ark. State Forestry Comn.; Ga. Forestry Comn., Ga. Forest Res. Council, Ga. Forestry Assoc.; La. Forestry Comn. (Bul. 12 of La. Forestry Comn.); and Miss. Forestry Assoc., Miss. Forestry Comn., Delta Council.
Booklet illustrating benefits and principles of hardwood management.

——— and Gantz, H. L.
1957. HEAVY, LIGHT OR NO CUTTING? Farm and Ranch (Southwest ed.) 87(6): 11, illus.
Improvement cuts made 15 years ago have greatly improved the quality of timber being grown in a once-depleted forest of bottom-land hardwoods.

* Maisenhelder, L. C., and Heavrin, C. A.
1957. SILVICS AND SILVICULTURE OF THE PIONEER HARDWOODS—COTTONWOOD AND WILLOW. Soc. Amer. Foresters Proc. 1956: 73-75.
Knowledge of the silvics of these two species is probably more complete than for most other commercially important hardwoods, good sites are abundant, and the trees grow exceptionally fast.

Putnam, J. A.
1955. GROWING HARDWOOD TREES AS A CROP. Forest Farmer 15(1): 6-7, 30-31, illus.
Describes a typically abused bottom-land hardwood stand and charts its potential development through intermediate cutting to a desirable structure.

* ———
1957. OPPORTUNITIES AND PROBLEMS IN THE SILVICULTURE OF SOUTHERN HARDWOODS. Soc. Amer. Foresters Proc. 1956: 62-64.
In southern hardwood silviculture we have the opportunity of putting a large part of the better class of our land to its best economic use, that of raising valuable timber of a class of which there is a threatening shortage, at a rate of up to 500 board feet, plus six-tenths of a cord . . . per acre per year. . . . The key to the situation is the generation of sufficient intelligent interest and determination amongst ourselves. The next step will be . . . to put into practice the rudimentary principles of management that we already know, and simultaneously to expand our scientific knowledge.

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1959. INITIAL MANAGEMENT OF HARDWOODS. Forest Farmer (Seventh Manual ed.) 18(8): 67-69, illus. *Also in* (Eighth Manual ed.) 19(7): 77-79, illus. 1960. *Also in* (Ninth Manual ed.) 20(7): 50-52, illus. 1961. *Also in* (Tenth Manual ed.) 21(7): 44-46, illus. 1962.
See next entry.

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1959. INITIAL MANAGEMENT OF HARDWOODS. Two parts. Forest Farmer 18(10): 6-8, 18-19, illus.; 18(11): 10-12, 18, illus.
Discussion of management in the light of hardwood utilization and marketing practices.

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1959. MANAGEMENT OF SOUTHERN HARDWOOD FORESTS RELATIVE TO THE SUPPLY OF RAILROAD STOCK. Cross Tie Bul. 40(2): 18-19, 22, 24-27.
" . . . When the present surplus of low grade timber on marginal or nonproductive sites is liquidated and when we get to managing the productive stands in earnest, it will be necessary to depend upon such productive stands for the permanent supply of railroad and construction material."

* ——— Furnival, G. M., and McKnight, J. S.
1960. MANAGEMENT AND INVENTORY OF SOUTHERN HARDWOODS. U. S. Dept. Agr. Agr. Handb. 181, 102 pp., illus.
The lower Mississippi Valley, lower Piedmont, and southern Coastal Plain from Virginia to Texas have long been recognized by the hardwood industries as the "southern hardwood territory." The moister parts of this area are better adapted to hardwoods than to pines, and about 45 million acres should be managed for continued hardwood production. This handbook brings together what is known about the management of these forests for timber production.

* Williston, H. L.
1959. INUNDATION DAMAGE TO UPLAND HARDWOODS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 123.
In north-central Mississippi, continuous flooding for 21 days during the summer caused greater mortality in yellow-poplar than in red and white oak, blackgum, sweetgum, and red maple. Trees were pole-size and larger.

Woods, F. W., and Shanks, R. E.
1957. REPLACEMENT OF CHESTNUT IN THE GREAT SMOKY MOUNTAINS OF TENNESSEE AND NORTH CAROLINA. Jour. Forestry 55: 847.
Blight-killed chestnuts are being replaced by various species of oak, mainly Quercus prinus *and* Q. rubra.

CONTROL OF UNWANTED VEGETATION

* CRAWFORD, H. S., JR.

1959. 2,4,5-T ON OZARK HARDWOODS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 120.

When applied in frills, 2,4,5-T rapidly killed crowns of unwanted oaks, hickories, and gums, but did not adequately suppress sprouting.

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1960. EFFECT OF AERIAL 2,4,5-T SPRAYS ON FORAGE PRODUCTION IN WEST-CENTRAL ARKANSAS. Jour. Range Mangt. 13: 44.

Grass increased during the first and second years after scrub oaks and hickories were killed. Yield of forbs declined sharply in the first year and rose the second, but much of the increase was in plants of low palatability to both cattle and deer. Browse declined with the death of the hardwoods, but recovered with the development of blueberry, grape, and other plants preferred by deer.

* ————

1960. SINGLE AERIAL SPRAY WITH 2,4,5-T EFFECTIVE ON HARDWOODS IN WEST-CENTRAL ARKANSAS. Ark. Farm. Res. 9(3): 6, illus.

Dosage per acre was 0.5 gallon of the iso-octyl ester, mixed with 1 gallon of diesel oil and 3.5 gallons of water. Basal sprouting was negligible and grass yields increased.

CROKER, T. C., JR.

1959. SCALPING STIMULATES LONGLEAF GROWTH. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 121.

On a sandy ridge in southern Alabama, scalping the seedbed just before seedfall markedly increased the number of longleaf pine seedlings that began height growth in their third year.

* DAVIS, J. R.

1956. 2,4,5-T—LOW-VOLATILE ESTERS EFFECTIVE. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 102.

See Davis, 1959.

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1958. BASAL SPRAY WITH 2,4,5-T FOR WINTER HARDWOOD CONTROL IN EAST TEXAS. Jour. Forestry 56: 349.

In applications during early winter, 2,4,5-T in diesel oil (23.5 lbs. ahg) controlled small sweetgum stems much better when used as a basal spray than when brushed on freshly cut stumps. Better results on stumps would be expected from applications during growing season.

* ————

1958. DILUTED 2,4,5-T MORE LETHAL THAN UNDILUTED IN EAST TEXAS. Jour. Forestry 56: 516.

For inhibiting sprouts from freshly cut post oak and sweetgum, 2,4,5-T was more effective when diluted with diesel oil than when undiluted, provided that the amount of acid equivalent in diluted and undiluted doses was equal.

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1959. LOW-VOLATILE 2,4,5-T EFFECTIVE AS BASAL SPRAY. Jour. Forestry 57: 851

A low-volatile ester was as good as a high-volatile ester in killing sweetgum.

* ———— and DUKE, W. B.

1955. QUICK, BUNYAN, THE NEEDLE! South. Lumberman 191 (2393): 171-172, illus.

Labor and other costs of using a tool designed to inject a tree-killing chemical solution into small hardwoods.

* DUMBROFF, E. B.

1960. AERIAL FOLIAGE SPRAYS FAIL TO ERADICATE SCRUB OAKS ON FLORIDA SANDHILLS. Jour. Forestry 58: 397-398.

Best results on oaks—but still inadequate for pine establishment—were achieved with propylene glycol butyl ether ester of 2-(2,4,5-TP) at 3 pounds acid equivalent per acre in an oil-water carrier. Grasses, which are as detrimental as scrub trees on these dry sites, were little affected by any phytocide.

DUNCAN, D. A., and WHITAKER, L. B.

1958. DEADENING SCRUB HARDWOODS LIVENS UP FORAGE. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 118.

In central Louisiana, deadening of hardwoods increased the protein and phosphorus content of the native forage, as well as the quantity of herbage per acre.

* FARRAR, R. M., JR.

1961. AERIAL APPLICATION OF FOUR SILVICIDES IN SOUTH ALABAMA. South. Weed Conf. Proc. 14: 198-201.

The butoxy ethanol ester of 2,4,5-T proved superior to three newer formulations for controlling scrub oaks with minimum damage to longleaf pine seedlings. Chemicals were applied at 2 pounds acid equivalent per acre.

* FERGUSON, E. R.

1958. PLOWS FOR WOODS PLANTING. South. Lumberman 197 (2465): 92-93, illus.

A V-shaped brush plow, mounted on front of the tractor pulling the planting machine, clears a planting strip by severing and uprooting small hardwoods, and throwing them into windrows.

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1958. RESPONSE OF PLANTED LOBLOLLY PINES TO REDUCTION OF COMPETITION. Jour. Forestry 56: 29-32, illus.

During dry years, first-year survival was best where competing hardwoods and grasses had been controlled, but during a year of well-distributed rainfall release had little effect on survival. Height growth increased roughly in proportion to the degree of release.

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1959. FURROWING INCREASES FIRST-YEAR SURVIVAL OF PLANTED PINE IN TEXAS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 124.

In a year of occasional droughts, seedlings that had been planted in shallow furrows survived better than those competing with undisturbed Bermuda grass.

* ———— and DUKE, W. B.

1956. COMPETITION AFFECTS FIRST-YEAR GROWTH. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 106.

Reduction of competition prior to sowing improved the height growth of loblolly seedlings in east Texas.

* GIBBS, C. B.
1959. AMINES OF 2,4-D HOLD PROMISE FOR HARDWOOD CONTROL. Down to Earth 15(3): 6.
The concentrated amine, applied in tree injector cuts, killed tops of 78 percent of the post oaks to which it was applied, and 58 percent of the sweetgums. Oaks did not sprout at all, and sprouts from sweetgums were small and few. The tests were in east Texas.

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1960. ISO-OCTYL ESTER OF 2,4,5-T FOR HARDWOOD CONTROL. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 126.
See next entry.

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1960. ISO-OCTYL ESTER OF 2,4,5-T IN HARDWOOD CONTROL. Weeds 8: 462-463.
Injections of 40-pound solutions killed sweetgums and oaks in east Texas; 20-pound concentrations appeared suitable for oaks alone.

* GRANO, C. X.
1955. BEHAVIOR OF SOUTH ARKANSAS OAKS GIRDLED IN DIFFERENT SEASONS. Jour. Forestry 53: 886-888, illus.
Fastest crown kill and least resprouting were secured when girdling was done in the spring. May seemed to be the best month.

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1955. GIRDLE YOUR WEED TREES IN THE SPRING. Forest Farmer 14(4): 6, 16, illus.
See preceding entry.

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1955. KILL WEED TREES IN SPRING. Prog. Farmer (Miss.-Ark.-La. ed.) 70(3): 103.
See second entry above.

* _____
1957. BULLDOZING TO CONTROL HARDWOOD BRUSH. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 109.
In south Arkansas, bulldozing to mineral soil controlled hardwood brush better than bulldozing at groundline followed by burning or by spraying with 2,4,5-T.

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1957. WHEN SHOULD CHEMICAL HARDWOOD CONTROL BE DONE? Forest Farmer 16(13): 12, illus.
In tests of southern red oaks in south Arkansas, spring was the best time to use 2,4,5-T in frills, but results at other seasons were also good.

* _____
1958. RESPONSE OF SOUTHERN RED OAK TO SEASONAL APPLICATIONS OF 2,4,5-T. Jour. Forestry 56: 140-141, illus.
In south Arkansas, spring applications of a 1-percent water mixture of the low-volatile esters of 2,4,5-T in frills gave faster crown kill and better sprout control than did application at any other season. Regardless of season of application, however, all crowns were dead two years after treatment. Sprouts also died off to negligible proportions.

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1961. HARDWOOD REOCCUPATION OF BULLDOZED SITES. *In* Hardwood Sprout Development on Cleared Sites, pp. 7-8, illus. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 186.
Dense thickets in south Arkansas were bulldozed. First-year sprouts were few, and the tallest averaged 1.8 feet. After 3 years one-fourth of the area was overtopped by sprouts; after 7 years half was overtopped by sprouts averaging 6 feet tall.

* _____
1961. MORTALITY OF LOBLOLLY PINE PLANTED UNDER SMALL HARDWOODS. U. S. Forest Serv. Tree Planters' Notes 48, pp. 1-2, illus.
Proportions of the plots overtopped by hardwoods varied from 25 to 87 percent at planting time. After 2 years, pine mortality ranged from 20 to 64 percent, being heaviest on plots most completely overtopped.

_____ and CLARK, R. H.
1958. TRACTOR-MOUNTED SPRAY FOR CONTROLLING SMALL HARDWOODS. South. Lumberman 196(2445): 28, illus.
Pictorial description.

* GRELEN, H. E.
1956. HOW ABOUT HELICOPTERS FOR SAND-HILL SCRUB OAK? South. Lumberman 193(2417): 247-248, illus.
The helicopter offers a fast, reasonably safe, and fairly inexpensive way to combat scrub oak in the Florida sandhills, provided that a chemical can be found that will prevent resprouting after the tops of the oaks have been killed.

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1958. SITE PREPARATION ON FLORIDA SANDHILLS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 114.
Heavy machines prepare satisfactory planting sites for pine, but oaks and wiregrass should be eradicated with a minimum of soil displacement. A heavy double-drum brush chopper is suitable.

* _____
1959. MECHANICAL PREPARATION OF PINE PLANTING SITES IN FLORIDA SANDHILLS. Weeds 7: 184-188, illus.
A heavy, double-drum brush chopper eliminates scrub oak and wiregrass while leaving the topsoil and vegetative debris on the planting site.

* _____
1960. SEASONAL FOLIAGE APPLICATIONS OF 2,4,5-T ON SAW-PALMETTO. Thirteenth South. Weed Conf. Proc. 1960: 109-112, illus.
Tests in the sandhills of northwest Florida suggest that effectiveness of 2,4,5-T varies with season of application and that 3.5 pounds ahg in a 1-to-9 oil-water carrier is as good as higher concentrations.

* HALLS, L. K.
1959. GALLBERRY (ILEX GLABRA [L.] GRAY). Handb.: Chemical Control of Range Weeds, pp. W-5, W-6. Range Seeding Equip. Com. U. S. Depts. Agr. and Int.
Chemicals and rates of application.

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1959. SAW-PALMETTO (SERENOA REPENS [BARTR.] SMALL). Handb.: Chemical Control of Range Weeds, pp. W-39, W-40. Range Seeding Equip. Com. U. S. Depts. Agr. and Int.
Chemicals and rates of application.

HARRINGTON, T. A.
1955. MORE POWER TO GIRDLING. Forest Farmer 14(8): 12, 16-17, illus.
In east Texas, a power tree girdler required 0.19 man-hour per 100 inches of tree diameter; hand girdling took 3 times as long.

* _____
1955. 2,4,5-T BASAL SPRAY ON HARDWOODS DOES NOT HARM LOBLOLLY PLANTED NEXT DAY. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 95.
See next entry.

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1956. LOBLOLLY SEEDLING SURVIVAL AFTER HARDWOOD CONTROL BY 2,4,5-T. Jour Forestry 54: 39-40.
Loblolly pine seedlings can be planted promptly on areas where hardwoods have been controlled with low-volatile esters of 2,4,5-T.

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1958. RELEASE DOUBLES SHORTLEAF SEEDLING GROWTH. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 113.

On the Cumberland Plateau of Tennessee, seedlings planted under hardwoods grew 3.4 inches in height the first year. Where the hardwoods were treated with 2,4,5-T, seedlings grew 8.3 inches.

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1959. 2,4,5-T EFFECTIVE FROM HELICOPTERS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 124. *Also in* Forestry Digest, p. 7. Feb. 1960.

On the Cumberland Plateau the oil solution of the iso-octyl ester reduced total crown coverage of low-grade hardwoods by 67 percent, two growing seasons after treatment. A water solution caused a 42-percent reduction.

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1960. IMMEDIATE RELEASE PAYS OFF. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 127.

On the Cumberland Plateau, underplanted shortleaf pines, released from low-grade hardwoods prior to their first growing season, grew twice as fast the first year and four times as fast the second as did unreleased seedlings.

——— and KRING, J. S.

1960. TIME FOR THE TREE INJECTOR. South. Lumberman 200 (2491): 40, 42, illus.

Man-hours per acre for injecting chemicals into unwanted hardwoods of eastern Tennessee can be estimated by multiplying the sum of the diameters to be treated by 0.0023 and adding 0.49.

* HEBB, E. A.

1957. REGENERATION IN THE SANDHILLS. Jour. Forestry 55: 210-212, illus.

Eradication of competing oaks and wiregrass is the key to successful pine establishment in the deep sands of western Florida.

HOPKINS, WALT.

1956. GROWING PINE IN THE SANDHILLS. Forest Farmer 15(5): 4-6, illus.

The Chipola Experimental Forest has demonstrated that pines can be grown in the Florida sandhills if competition from oaks and wiregrass is reduced.

* HUCKENPAHLER, B. J.

1955. UNDERPLANTED LOBLOLLY PINE RESPONDS TO DELAYED RELEASE. Jour. Forestry 53: 512.

Even when delayed for as long as 8 years, release from overstory hardwoods greatly stimulated pine growth in north Mississippi.

* JOHNSON, R. L.

1959. FRILLS MUST BE COMPLETE. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 119.

Even though a chemical is poured into the cut, a cull hardwood may survive if any cambium has been left unsevered.

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1961. HARDWOOD SPROUTS DOMINATE BOTTOM-LAND CLEARINGS. *In* Hardwood Sprout Development on Cleared Sites, p. 9, illus. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 186.

Five years after they had been bulldozed, openings were dominated by sprout trees, mainly bitter pecan and green ash.

KRINARD, R. M.

1960. DEADENING VINES FAILS TO IMPROVE COTTONWOOD GROWTH. Miss. Farm Res. 23(5): 3, 5.

Trees whose crowns were freed of vines grew no faster than untreated trees, which averaged 45 vines apiece, some of them 3 inches in diameter.

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1960. TREE INJECTOR WORKS ON BOTTOM-LAND HARDWOODS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 130.

It was tested on bitter pecan and overcup oak in the Mississippi Delta.

* LAWSON, E. R.

1959. 2,4,5-T BETTER IN DIESEL OIL. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 119.

In the Ouachita Mountains, 2,4,5-T in diesel oil, applied with a tree injector, killed the crowns of 98 percent of treated white oaks in a year. The same concentration in a water carrier gave a 65-percent kill.

* MCCLURKIN, D. C.

1958. MALEIC HYDRAZIDE FAILS TO CONTROL FERTILIZED BERMUDAGRASS. U. S Forest Serv. Tree Planters' Notes 33, p. 29.

Loblolly pines were planted on an eroded site in north Mississippi and heavily fertilized. Maleic hydrazide, applied in May, did not retard the Bermudagrass, which by the end of the season had killed many pine seedlings.

MCKNIGHT, J. S., and MCWILLIAMS, J. S.

1957. IMPROVING SOUTHERN HARDWOOD STANDS THROUGH COMMERCIAL HARVEST AND CULL-TREE CONTROL. Soc. Amer. Foresters Proc. 1956: 71-72.

Perhaps one-fifth of the growing space of productive hardwood sites is occupied by culls. Most of the methods of cull-tree control being used in other timber types and regions also work well in the southern hardwoods, but all trees to be removed should be marked by a forester familiar with hardwood quality and utilization.

* MAISENHELDER, L. C.

1958. UNDERSTORY PLANTS OF BOTTOMLAND FORESTS. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 165, 40 pp., illus.

Pictorial descriptions, plus a brief text, to aid recognition of 36 understory plants in river-bottom forests of the Midsouth.

* MAPLE, W. R.

1960. ROTARY CUTTER PREPARES PINE SEEDBED FOR NATURAL REGENERATION WHILE CLEARING BRUSH. U. S. Forest Serv. Tree Planters' Notes 40, pp. 17-19, illus.

In the Arkansas Ozarks, site treatment with the brush cutters resulted in a better seedling catch, following the bumper 1957 shortleaf pine cone crop, than was obtained with prescribed burning or chemical control of small hardwoods.

MIGNERY, A. L.

1956. BASAL SPRAY CONTROLS IRONWOOD AND HAWTHORN. Tex. Forest News 35(4): 10.

The spray was 2,4,5-T in diesel oil, applied in December.

* ———

1956. WHAT GIVES WITH GIRDLING? South. Lumberman 193 (2417): 214-215, illus.

Experience of east Texas landowners indicates that trees girdled by machine die more slowly than those treated with chemicals, but that the amount of growing space opened up is practically the same. Machine-made girdles bridged over somewhat more frequently than ax-and-poison treatments.

PEEVY, F. A.

1956. METHODS FOR CONTROLLING HARDWOODS. Forests and People 6(3): 22-25, 34-35, illus.

Chemicals, dosages, season and methods of application, and costs.

* PEEVY, F. A.
1959. FOLIAR APPLICATION. Forests and People 9(2): 20-21, 46, illus.
For controlling cull hardwoods from the air, 2 pounds acid equivalent of a low-volatile ester of 2,4,5-T in an oil-water emulsion (3.5 gallons of water and 1.5 gallons of oil and herbicide) is effective and economical. For application from the ground, 2 to 4 pounds acid equivalent of the low-volatile 2,4,5-T ester per 100 gallons of carrier (98 gallons of water and 2 gallons of oil and herbicide) gives good results; rate of application may vary from 30 to 200 gallons of mixture per acre, depending on density and height of brush.

* _____
1959. METHODS OF APPLYING HERBICIDES FOR CONTROLLING INDIVIDUAL WEED TREES. Forests and People 9(3): 31, 42-43, illus.
Unwanted hardwoods can be killed by injecting 2,4,5-T into the trunk, or by injecting fenuron into the soil at the base of the tree. In central Louisiana, costs of chemical and labor per inch of trunk diameter were one-fourth to one-third cent for tree injections and one-half cent for soil injections.

_____
1960. A COMPARISON OF DIFFERENT PLACEMENTS OF 2,4,5-T ESTER APPLIED AS A BASAL SPRAY FOR CONTROL OF BLACKJACK OAK. South. Weed Conf. Proc. 13: 200-204.
Best kill appears to result from application to the rootcollar and sprouting zone at the base of trees.

* _____
1960. CONTROLLING SOUTHERN WEED TREES WITH HERBICIDES. Jour. Forestry 58: 708-710, illus.
Costs and methods of using silvicides in frills or notches, as basal sprays, with tree injectors, as foliar sprays from the ground or air, and as soil applications.

* _____
1960. SOIL APPLICATION OF CHEMICALS FOR CONTROL OF SOUTHERN UPLAND HARDWOODS. Forests and People 10(1): 24-25, 37, illus.
Fenuron and monuron killed oaks when applied in late winter or spring at rates of 0.5 to 1.0 gram of active material per inch of trunk diameter. Fenuron was the most effective, and its residue seemed less damaging to pines.

* _____
1961. BASAL APPLICATION OF HERBICIDES FOR CONTROL OF WOODY PLANTS. *In* The Use of Chemicals in Southern Forests. La. State Univ. Ninth Ann. Forestry Symposium Proc. 1960: 66-70.
Chemicals and methods of application in frills or notches, as basal stem sprays, with tree injectors, and to the soil.

* _____
1961. CONTROL OF BLACKJACK OAK BY BASAL SPRAYING WITH 2,4,5-T. Weeds 9: 50-53, illus.
Best treatment was 8 pounds of 2,4,5-T per 100 gallons of oil, applied in a band 8 inches wide at rate of 64 milliliters of solution per inch of trunk diameter.

* _____
1961. KILLING WOODY PLANTS WITH HERBICIDES. South. Weed Conf. Proc. 14: 208-217.
Chemicals and dosages for foliar spraying from ground or air, trunk injections, soil treatment, stem spray, and applications on stumps and in frills or notches.

* _____
1961. TESTING THE NEW HERBICIDES. Forests and People 11(2): 20-21, 36-37, illus.
Of 9 new herbicides, none was better than 2,4,5-T for general use, though some proved equally good for specific purposes.

_____ and BURNS, P. Y.
1959. EFFECTIVENESS OF AERIAL APPLICATION OF HERBICIDES FOR HARDWOOD CONTROL IN LOUISIANA. Weeds 7: 463-469, illus.
Of 7 herbicidal treatments, the most effective was the butoxyethanol ester of 2,4,5-T in oil-water emulsion. The propylene glycol butyl ether ester of silvex in oil-water emulsion was as effective as the 2,4,5-T ester on hickory and on blackjack, red, and post oak, but less effective on sweetgum, blackgum, and white and black oak.

* REYNOLDS, R. R.
1956. UPLAND HARDWOODS IN SOUTH ARKANSAS PINE STANDS—AERIAL OR UNDERGROUND FIFTH COLUMN? Jour. Forestry 54: 585-586, illus.
Sprouting from old rootstocks, and not new seeding from distant untreated areas, seems to account for nearly all the hardwood brush that often comes in under pine stands in which the seed-bearing hardwoods have been killed.

* RUSSELL, T. E.
1961. COMPLETE RELEASE BEST ON CUMBERLAND PLATEAU. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 133.
Three years after they were underplanted, loblolly pines were tallest where both understory and overstory competition had been eliminated—and taller where silvicide had been used than where hardwoods had simply been cut or girdled.

* _____
1961. CONTROL OF UNDERSTORY HARDWOODS FAILS TO SPEED GROWTH OF POLE-SIZE LOBLOLLY. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 131.
During 6 years, growth averaged 172 cubic feet per acre annually in untreated stands and 175 cubic feet where all hardwoods had been removed. The plantation, in central Louisiana, was 26 years old when the study began.

* _____
1961. 'COPTER CONTROL FOR CUMBERLAND CULLS. South. Lumberman 203(2537): 169-170, illus.
In a 600-acre test in southeastern Tennessee, helicopter application of 2,4,5-T in diesel oil eliminated enough overstory hardwoods to insure survival and early growth of planted pines. A water solution was less effective.

* _____ and RHAME, T. E.
1960. DISK BEFORE SEEDING SLASH PINE. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 130.
See next entry.

* _____ and RHAME, T. E.
1961. THE ADVANTAGES OF DISKING FOR SLASH SEEDING. Forests and People 11(1): 12-13, illus.
In central Louisiana, cost of disking a seedbed was offset by increased growth and survival of direct-seeded slash pines.

* SCHEER, R. L.
1958. INTENSIVE SITE PREPARATION STIMULATES LONGLEAF GROWTH ON SANDHILLS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 115.
Complete removal of competing wiregrass and scrub oaks considerably speeded height growth of planted longleaf pine.

* ——— and Woods, F. W.
1959. INTENSITY OF PREPLANTING SITE PREPARATION REQUIRED FOR FLORIDA'S SANDHILLS. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 168, 12 pp., illus.
Complete removal of competing scrub oaks and wiregrass was found necessary for consistently satisfactory survival of planted slash pine. Bulldozing accomplishes this degree of site preparation, but methods that leave topsoil in place are preferable.

Shoulders, Eugene.
1955. CONSERVING LOUISIANA'S LOBLOLLY PINE. Forests and People 5(4): 36-37, 45, illus.
Prompt release benefits underplanted pines.

* ———
1955. PUTTING OZARK FORESTS TO WORK. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 98.
Many depleted Ozark woodlands could be put back to work quickly if their owners would sell undesirable growing stock and use part of the returns to deaden culls.

* ———
1955. RELEASE UNDERPLANTED LOBLOLLY EARLY. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 100.
In Louisiana, pines released immediately after they were planted beneath overstory hardwoods grew and survived better than those released 1 or 2 years later.

* ———
1956. TIMBER STAND IMPROVEMENT IN OZARK FORESTS—AN APPRAISAL AFTER 15 YEARS. Jour. Forestry 54: 824-827, illus.
Benefits are most noticeable in the understory, where basal area and stem quality have improved in proportion to the amount of overstory removed. Cleaning around understory crop trees also stimulated growth, but only when done in conjunction with overhead release.

* ———
1957. SCALPING BOOSTS PLANTING SURVIVAL. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 110.
See next entry.

* ———
1957. SITE PREPARATION—DOES IT PAY? Forests and People 7(3): 20-21, 23, illus.
In central Louisiana, more pine seedlings survived the first year on prepared than on unprepared sites. Site preparations tested were scalping, triple-disking in strips, and shallow and deep furrowing with a Mathis plow. Scalping appeared to be the most effective practical treatment, as it was done with standard attachments to the Lowther tree planter.

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1958. SCALPING—A PRACTICAL METHOD OF INCREASING PLANTATION SURVIVAL. Forest Farmer 17(10): 10-11, illus.
See preceding entry.

* Siegel, W. C.
1960. DELAY IN RELEASE STUNTS LOBLOLLY GROWTH. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 128.
In central Mississippi, 13-year-old natural loblolly pines that had been released at age 3 years were twice as tall as those freed at age 8, but less than half the height of trees that had been planted in the open.

* Smalley, G. W.
1958. STAND IMPROVEMENT PAYS OFF. South. Lumberman 197 (2465): 100-102, illus.
In a pine-hardwood stand near Birmingham, Alabama, pine growth was best on plots given the most intensive treatment. This treatment consisted of selling all merchantable hardwoods, felling or girdling all unmerchantable hardwoods 2 inches or more in d.b.h., and cutting hardwoods less than 2 inches in diameter if they were overtopping pines.

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1959. GIRDLE OR FELL OAKS TO RELEASE PINES? U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 122.
Methods of release made no difference in soil moisture, nor in the survival or growth of underplanted loblolly seedlings.

Smith, J. L.
1959. BENZOIC ACID INEFFECTIVE ON HARDWOODS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 122.
The chemical was applied to the soil surface both broadcast and around individual white oak root-collars. It had little effect on the oaks, but broadcast application killed practically all shortleaf pines up to 12 inches d.b.h.

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1959. TESTS OF INJECTED CHEMICALS FOR HARDWOOD CONTROL IN THE ARKANSAS MOUNTAINS. Twelfth South. Weed Conf. Proc. 1959: 123-125.
Three formulations were effective. They were the 44-pound ahg concentrations of butoxy ethanol esters of mixed 2,4-D and 2,4,5-T; of butoxy ethanol ester of 2,4,5-T; and of the 2-ethyl-hexyl ester of 2,4,5-T.

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1959. 2,4,5-T CONCENTRATIONS FOR TREE INJECTION IN THE ARKANSAS OUACHITAS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 123.
Heavy concentrations were required to give adequate first-year kill of cull white oaks.

* ———
1960. HARDWOOD REMOVAL LESSENS LITTER-HUMUS IN OZARKS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forest Res. 1: 9-10.
Weight of the litter-humus layer declined by half within a year after hardwoods were killed with 2,4,5-T sprays. Corresponding reductions were noted in retention storage of moisture, and greater ones in detention storage.

* ———
1960. MIST BLOWER FOR CONTROLLING UNDESIRABLE HARDWOODS. South. Lumberman 201(2513): 185-186, illus.
Tests near Hot Springs, Arkansas, indicated that mist blowers will do a good job where small hardwoods are too numerous for single-stem treatment or too well protected by the overstory for airplane spraying.

* ———Bower, D. R., and Lawson, E. R.
1960. SITE PREPARATION AIDS PINE SEEDING IN OUACHITAS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 129.
Baring mineral soil by burning or furrowing consistently improved stocking and survival of direct-seeded shortleaf pine. Mere deadening of hardwoods was inadequate.

* ——— and Lawson, E. R.
1960. HERBICIDAL SPRAYS DAMAGE PINE SEEDLINGS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 125.
In the Ouachita Mountains, foliage spraying with 2,4,5-T to control understory hardwoods was lethal to newly germinated shortleaf seedlings.

* SMITH, J. L., and LAWSON, E. R.
1960. LATE SPRAYS KILL HARDWOODS IN WET YEAR. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 125.
In the Ouachitas, foliage sprays of 2,4,5-T controlled undesirable hardwoods as effectively in the late growing season as in spring, provided that soil moisture remained adequate for tree growth.

* STEPHENSON, G. K., and GIBBS, C. B.
1959. SELECTIVE CONTROL OF CULL HARDWOODS IN EAST TEXAS. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 175, 10 pp., illus.
Techniques for deadening individual trees—as distinguished from broadcast methods of cull-tree control. Mechanical girdling has been found cheaper than ax work, but both kinds of girdles need chemical supplements to prevent sprouting. Esters of 2,4,5-T are effective as supplements to girdling, or as basal sprays or injections.

* STRANSKY, J. J.
1959. CONCENTRATED OR DILUTED 2,4,5-T AS A SUPPLEMENT TO GIRDLING? Jour. Forestry 57: 432-434, illus.
Concentrated and diluted 2,4,5-T were equally effective in killing crowns of post oak and sweetgum in east Texas, but the concentrate was a poor sprout inhibitor and the dilute solution a very good one. Growing-season treatments were better than dormant-season applications. Ax girdles were more effective than machine girdles when no chemical was applied, but with chemicals the differences were insignificant.

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1959. SITE TREATMENTS HAVE LITTLE EFFECT DURING WET SEASON IN TEXAS. U. S. Forest Serv. Tree Planters' Notes 36, pp. 20-21.
Though no treatment significantly improved either survival or height growth in a wet spring, flat-breaking seemed to offer possibilities for a dry year. Burning greatly reduced the cost of mechanical site preparation in bushy old fields.

* ———
1961. WEED CONTROL, SOIL MOISTURE, AND LOBLOLLY PINE SEEDLING BEHAVIOR. Jour. Forestry 59: 282-284, 289-290, illus.
In a critical drought, plots on which weeds and grasses were best controlled had most soil moisture and best pine survival. The study was in east Texas; droughts are frequent here and the investigation indicated the advisability of preparing sites before planting pines.

WILLISTON, H. L.
1956. WHAT HAPPENS WHEN YOU FREE SUPPRESSED PINES. Forest Farmer 15(9): 12, illus.
Even pines that seem hopelessly suppressed will usually recover if low-grade hardwoods are deadened.

* ———
1959. TEN-YEAR RESULTS OF RELEASING LOBLOLLY PINE. Miss. Farm Res. 22(10): 3-4, illus.
The pines were underplanted in 1941 on a blackjack-post oak ridge in Mississippi and released after 8 growing seasons. While earlier control of the overstory would have been preferable, diameter growth in 1948-1958 was 2½ times as great as for unreleased pines, and height growth 1 to 1½ times as great.

* ———
1960. KILLING HARDWOODS WITH 2,4,5-T. Miss. Farm Res. 23(10): 2.
Frilling or machine-girdling hardwoods without use of 2,4,5-T will release pine seedlings that are vigorous and at least 3 feet tall. Where the pines are smaller, 2,4,5-T should be used in a frill or girdle. Frills seem to kill hardwood crowns faster than machine girdles do.

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1961. INTENSIVE EARLY RELEASE PROMOTES GROWTH OF PINES. Miss. Farm Res. 24(10): 5.
Immediate and complete removal of competing hardwoods increased soil moisture and improved survival and growth of underplanted pines. Delayed or partial release was less effective.

* ——— and HUCKENPAHLER, B. J.
1958. RESPONSE OF SIX CONIFERS IN NORTH MISSISSIPPI UNDERPLANTINGS. Jour. Forestry 56: 135-137, illus.
Immediate release from hardwood competition greatly stimulates the height growth of seedlings. Loblolly pine has outgrown other conifers and appears to be the best of the species tested for restocking hardwood stands on dry loessial ridges. On a soil with rapid internal drainage, shortleaf and Virginia pine survived better than loblolly during drought years. Eastern redcedar survived well but has been severely browsed by deer. Slash pine and longleaf did not perform well.

* ——— and MCCLURKIN, D. C.
1961. SOIL MOISTURE-SEEDLING GROWTH RELATIONS IN CONVERSION PLANTING OF OAK RIDGES TO PINE. Jour. Forestry 59: 20-23, illus.
On a loessial ridge in north Mississippi, more soil moisture was available to loblolly pines where all hardwoods had been treated than where only the overstory or only the understory stems had been removed. Overstory hardwoods appeared to draw more moisture from upper soil zones than did understory hardwoods, but both classes drew equally from lower depths.

WOODS, F. W.
1955. CONTROL OF WOODY WEEDS: SOME PHYSIOLOGICAL ASPECTS. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 143, 50 pp.
A review of present knowledge, with emphasis on changes in carbohydrate metabolism.

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1955. TESTS OF A SOIL STERILANT FOR FORESTRY USE. Sci. 122: 332.
See next entry.

* ———
1955. TESTS OF CMU FOR FORESTRY. Forest Sci. 1: 240-243, illus.
In the sandhills of western Florida, CMU killed scrub oaks when applied to the soil in dosages of 11 pounds per acre. Much higher dosages were needed to eliminate wiregrass and other ground cover. Slash pine seedlings planted 9 months after application were damaged or destroyed on all plots where the dosage had been 4 pounds or more per acre.

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1955. TESTS OF TWO SOIL STERILANTS FOR FORESTRY USE. Eighth South. Weed Conf. Proc. 1955: 249-254, illus.
At dosages of 120 pounds per acre, TCA killed 83 percent of the trees and nearly all of the lesser vegetation on Florida sandhills. It reached maximum effectiveness in 60 days after application, and did not interfere with slash pines planted 9 months after application. For performance of CMU, see abstract immediately above.

* ————

1956. RELATION OF SOIL MOISTURE AND TEMPERATURE TO WEED CONTROL. Ninth South. Weed Conf. Proc. 1956: 161-165, illus.

On sandhill sites in west Florida, complete eradication of oak and wiregrass improved the survival of planted slash pine by decreasing the competition for soil moisture.

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1956. SITE PREPARATION HELPS PLANTED PINES. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 103. *Also in* The Unit, News Letter 66, p. 31.

See preceding entry.

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1958. SOME EFFECTS OF SITE PREPARATION ON SOIL MOISTURE IN SANDHILLS OF WEST FLORIDA. Soil Sci. 85: 148-155, illus.

Soil moisture in the 3- to 9-inch layer was closely and positively related to pine seedling survival.

* ————

1959. CONVERTING SCRUB OAK SANDHILLS TO PINE FORESTS IN FLORIDA. Jour. Forestry 57: 117-119, illus.

For best survival and growth of pine plantations on the Florida sandhills, sites should be completely cleared of oaks and wiregrass. Two treatments with a double-drum brush chopper are recommended—the first in late April or early May, the second not less than 6 weeks later.

* ———— and CASSADY, J. T.

1961. SPROUTING OF SANDHILLS SCRUB OAKS FOLLOWING CUTTING. *In* Hardwood Sprout Development on Cleared Sites, pp. 1-6, illus. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 186.

Turkey and bluejack oaks in the sandhills of western Florida were cut 4 inches above the ground in May, and sprouts were removed twice thereafter during the same growing season. Removals at 6 or 8 weeks apart were better than those at 4-week intervals.

————CASSADY, J. T., and ROSSOLL, HARRY.

1958. HOW TO PREPARE GULFCOAST SANDHILLS FOR PLANTING PINES. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 161, 11 pp., illus.

Pictorial description.

* ———— HARRIS, H. C., and CALDWELL, R. E.

1959. MONTHLY VARIATIONS OF CARBOHYDRATES AND NITROGEN IN ROOTS OF SANDHILL OAKS AND WIREGRASS. Ecol. 40: 292-295, illus.

Oaks (Quercus laevis, Q. incana) *reached their lowest natural ebb of carbohydrates in late April or early May; total nitrogen in oak roots was lowest in the first week of June. In wiregrass* (Aristida stricta) *carbohydrates were at low point in mid-July and nitrogen in September.*

YOCOM, H. A.

1955. MACHINE FASTER THAN AX IN GIRDLING. Jour. Forestry 53: 205-206.

A gasoline-powered machine was found twice as fast as an ax for girdling unwanted hardwoods in north-central Alabama; a formula was developed to predict the time required for machine girdling.

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1958. DEEP GIRDLES GIVE QUICKEST CROWN KILL OF OAKS. Jour. Forestry 56: 217, illus.

In north Alabama, completely severing the sapwood kills the crowns of upland oaks much quicker than do shallower girdles.

* ————

1958. MACHINE GIRDLING COMPARED TO AX. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 115.

Oaks girdled by machine took somewhat longer to die than those that were double-hacked or frilled.

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1959. HARDWOOD CONTROL METHODS. Ala. Forest Prod. 2: 124-126, illus.

Brief review.

FIRE

* BRUCE, DAVID.

1955. LONGLEAF LED THE WAY. La. State Univ. Fourth Ann. Forestry Symposium Proc. 1955: 79-83.

Longleaf pine was the first U. S. forest type in which fire was used silviculturally. The species' natural fire resistance, and the fuels and soils characteristic of longleaf sites, make successful prescribed burning easier than in the loblolly-shortleaf type.

* ————

1956. YOUNG LONGLEAF DO BEST ON FRESH BURNS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 101.

Age of rough influences early growth and survival.

* ———— and NELSON, R. M.

1957. USE AND EFFECTS OF FIRE IN SOUTHERN FORESTS: ABSTRACTS OF PUBLICATIONS BY THE SOUTHERN AND SOUTHEASTERN FOREST EXPERIMENT STATIONS, 1921-55. U. S. Forest Serv. Fire Control Notes 18(2): 67-96.

FAHNESTOCK, G. R.

1958. BORATE FIRELINES TOXIC TO SOUTHERN VEGETATION. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 118.

See second entry below.

* ————

1959. WHEN WILL THE BOTTOM-LANDS BURN? Forests and People 9(3): 18-19, 44-45, illus.

In the Louisiana Delta, during the period August 1 and March 31, number of days with fires, fires per day, and area burned all increase sharply when rainfall for the preceding 60 days dips below 8 inches. The fire situation continues to worsen as 60-day rainfall declines further.

* ———— and JOHANSEN, R. W.

1960. WILL BORATE KILL SOUTHERN TIMBER? U. S. Forest Serv. Fire Control Notes 21(3): 87-93, illus.

Both in Georgia and Louisiana, sodium calcium borate is toxic to pines when used at the rates required for fireline construction.

FERGUSON, E. R.

1955. FIRE-SCORCHED TREES—WILL THEY LIVE OR DIE? La. State Univ. Fourth Ann. Forestry Symposium Proc. 1955: 102-111, illus.

Interim results from an east Texas study suggest that salvage after a fire should be concentrated first on pines that have had all their foliage consumed, then on those that have suffered complete crown scorch and very severe or very extensive bark scorch. Trees damaged in summer fires are more likely to succumb than those damaged at other seasons. Shortleaf pines are poorer risks than loblolly or longleaf.

FERGUSON, E. R.
1957. PRESCRIBED BURNING IN SHORTLEAF-LOBLOLLY PINE ON ROLLING UPLANDS IN EAST TEXAS. U. S. Forest Serv. Fire Control Notes 18(3): 130-132, illus.
Large test burns on rolling uplands in east Texas have proved variable and only moderately effective in controlling undesirable hardwood understory. This is in contrast to encouraging results on small plots.

* ———
1957. STEM-KILL AND SPROUTING FOLLOWING PRESCRIBED FIRES IN A PINE-HARDWOOD STAND IN TEXAS. Jour. Forestry 55: 426-429, illus.
Hardwoods under 1.5 inches in diameter were controlled much more readily than larger ones. More tops were killed by headfires than by backfires, and fires during the growing season were more effective than those at other times. Fires that caused high mortality and damage in hardwoods also killed the most small pines.

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1958. AGE OF ROUGH (GROUND COVER) AFFECTS SHORTLEAF PINE ESTABLISHMENT AND SURVIVAL. Jour. Forestry 56: 422-423, illus.
Prescribed burns were made at four times of the year and at intervals of 3 to 43 months prior to the heavy shortleaf pine seed crop of 1955. After a dry winter, germination averaged 3.7 percent, but was substantially less where burns had been made 2 or 3 years prior to seedfall. First-year survival was better on growing-season burns than on dormant-season burns.

* ———
1958. PRESCRIBED BURNING AS AN AID IN REGENERATING DIFFICULT AREAS. Gulf States Sect. Soc. Amer. Foresters Proc. 1958: 35-41.
Prescribed fires can be used to improve seedbeds and to control unwanted hardwoods on areas that could not be regenerated to pine without such preparation. Other methods may give better results than fire but will generally be more costly.

* ———
1961. EFFECTS OF PRESCRIBED FIRES ON UNDERSTORY STEMS IN PINE-HARDWOOD STANDS OF TEXAS. Jour. Forestry 59: 356-359, illus.
Proportionately more hardwood than pine stems were killed back, but most damaged pines died and 90 percent of the hardwoods resprouted. Sweetgum was more susceptible than oak, fires in the growing season killed more hardwoods than did winter burns, and 1- and 2-inch stems of all species were more readily killed than larger ones.

——— GIBBS, C. B., and THATCHER, R. C.
1960. "COOL" BURNS AND PINE MORTALITY. U. S. Forest Serv. Fire Control Notes 21(1): 27-29, illus.
Assessments of fire damage, for salvage or other purposes, should not be limited to scorched crowns and trunks, but should also include low basal scorch, particularly following slow, low-burning ground fires in areas with heavy litter accumulations.

* GWINNER, M. W., and FAHNESTOCK, G. R.
1961. BORATE EFFECTS AFTER THREE YEARS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 133.
Pines and other forest vegetation are recovering from an experimental spraying with a fire-retardant slurry of sodium calcium borate. Where dosages were heavier than would be required for operational firelines, considerable ground is still bare. See Fahnestock and Johansen, above.

* HARE, R. C.
1960. DETECTING DEAD CAMBIUM WITH A MOISTURE METER. Jour. Forestry 58: 815-817, illus.
Cambium loses electrical conductivity soon after it dies. A lumber moisture meter, with probes insulated except at the very tips, can therefore be used for rapid and non-injurious separation of living and dead trees in recently burned stands. The meter can also measure bark thickness.

* ———
1961. HEAT EFFECTS ON LIVING PLANTS. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 183, 32 pp.
Literature review, with recommendations for research into physiological effects of high temperature on woody plants.

HARRINGTON, T. A., and STEPHENSON, G. K.
1955. REPEAT BURNS REDUCE SMALL STEMS IN TEXAS BIG THICKET. Jour. Forestry 53: 847.
Prescribed spring burns repeated at short intervals reduced understory hardwoods.

JORGENSEN, JACQUES, and DERR, H. J.
1958. YEARLING LONGLEAF SURVIVES A WILDFIRE. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 114.
If weather is favorable during the first year, longleaf seedlings may reach a size that enables them to survive some accidental fires.

* MANN, W. F., JR., and GUNTER, E. R.
1960. PREDICTING THE FATE OF FIRE-DAMAGED PINES. Forests and People 10(1): 26-27, 43, illus. *Also in* Forest World, pp. 5-7. June 1962.
Proportion of live crown with needle scorch and, secondly, the extent of cambium kill at groundline appeared to be better indicators of mortality than height of bark charring, length of live crown with needles consumed, presence of bark beetles, or pitch bleeding. No differences were noted between loblolly, shortleaf, and slash pine.

* ——— and GUNTER, E. R.
1960. THE ODDS FOR A FIRE-DAMAGED PINE TO DIE. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 126.
See preceding entry.

* ——— and RHAME, T. E.
1955. PRESCRIBE-BURNING PLANTED SLASH PINE. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 96.
Slash pine plantations under 8 feet tall can be burned when conditions are optimum and personnel are experienced, but it is risky business.

——— and WHITAKER, L. B.
1955. EFFECTS OF PRESCRIBE-BURNING 4-YEAR-OLD PLANTED SLASH PINE. U. S. Forest Serv. Fire Control Notes 16(3): 3-5.
A 600-acre plantation in central Louisiana was burned in late winter, primarily to reduce an old rough that had become a fire hazard. Mortality from the fire was 8 percent, mostly in trees so small that they were unlikely to reach merchantable size. In the first year after the fire, survivors with more than half of their needles scorched made somewhat less height growth than unburned seedlings.

* NELSON, R. M., and BRUCE, DAVID.
1958. FOREST FIRE RESEARCH NEEDS IN THE SOUTH. Jour. Forestry 56: 399-403.
Subjects for research are ignition and combustion processes, fuel characteristics, weather and fire behavior, fire danger measurement, human relations affecting fire prevention, suppression techniques, direct and indirect fire effects, and techniques of fire use.

* SMITH, J. L., and BOWER, D. R.
1961. BURNING DESTROYS DUFF-STORED SEED. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 131.
Shortleaf pine seed in the Ouachita Mountains of Arkansas sometimes lies in the duff for a year before it germinates. Untimely controlled burning for seedbed preparation can destroy such seed and thus reduce the crop of natural seedlings.

THOMAS, A. A.
1956. THE CHRISTMAS EVE BURN. Amer. Forests 62(3): 28-29, 60, illus. *Also in* U. S. Forest Serv. Fire Control Notes 17(4): 9-12, illus.
A prescribed burn saved $2,000 worth of longleaf seedlings in south Alabama. Cost of the burn was less than $100, and damage to the seedling stand not more than $50.

* TOOLE, E. R., and MCKNIGHT, J. S.
1955. FIRE AND THE HAPLESS HARDWOOD. South. Lumberman 191(2393): 181-182, illus.
A bottom-land hardwood tract that had suffered a wildfire suffered complete mortality in the seedling component and tremendous damage to larger trees. The article suggests guides for salvaging fire-damaged timber and for estimating the extent of the rot behind old wounds.

——— and MCKNIGHT, J. S.
1955. FIRE DAMAGE TO HARDWOOD TREES SHOWN IN DELTA. Miss. Farm Res. 18(9): 1, 8, illus. *Also as* Miss. Agr. Expt. Sta. Serv. Sheet 432, 2 pp., illus.
See preceding entry.

* ——— and MCKNIGHT, J. S.
1956. FIRE EFFECTS IN SOUTHERN HARDWOODS. U. S. Forest Serv. Fire Control Notes 17(3): 1-4, illus.
See second entry above.

——— and MCKNIGHT, J. S.
[1957.] FIRE PREVENTION A MUST IN GROWING HARDWOOD. Miss. Forestry Assoc., 2 pp., illus.
See third entry above.

REGENERATION

* ALLEN, R. M.
1955. FOLIAGE TREATMENTS IMPROVE SURVIVAL OF LONGLEAF PINE PLANTINGS. Jour. Forestry 53: 724-727, illus.
Partially clipping the needles of longleaf pine planting stock can reduce transpiration and improve field survival. Wax foliage coatings have sometimes improved and sometimes reduced survival.

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1955. GROWTH OF PLANTED LONGLEAF PINE ON CUTOVER LAND AND OLD FIELDS. Jour. Forestry 53: 587, illus.
In south Mississippi, satisfactory longleaf pine stands were obtained in 10 years by planting 1,500 to 2,000 seedlings per acre on old fields. On cutover land, where competition from grass and brush was more intense, similar plantings yielded inadequate stands.

———
1956. RELATION OF SAW-PALMETTO TO LONGLEAF PINE REPRODUCTION ON A DRY SITE. Ecol. 37: 195-196, illus.
Pine seedlings were found only near clumps of saw-palmetto. Apparently the palmetto shade protected the seedlings from lethal temperatures and improved their water relations.

* ——— and MCCOMB, A. L.
1956. ROOTING OF COTTONWOOD CUTTINGS. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 151, 10 pp., illus. *Also as* ÜBER FAKTOREN, DIE DIE BEWURZELUNG DER STECKLINGE VON DER POPULUS DELTOIDES BARTR. BEEINFLUSSEN. Zentbl. f. das Gesam. Forstw. 74(4): 199-220, illus. 1955
Rooting ability decreased as age of the cutting wood increased from 1 to 4 years. Indoleacetic acid or indole-n-butyric acid stimulated rooting but retarded top growth. The higher the moisture level of the soil, the better was the survival and rooting.

——— and MAKI, T. E.
1955. RESPONSE OF LONGLEAF PINE SEEDLINGS TO SOILS AND FERTILIZERS. Soil Sci. 79: 359-362.
Even though they may be of the same green weight, seedlings grown in different soils can differ in ability to survive after being transplanted.

* ——— and SCARBROUGH, N. M.
1960. GROWTH OF SLASH PINE AND POND PINE ON WET SITES. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 125.
Seven years after being planted on wet sites in southern Mississippi, Pinus elliottii *averaged 7.2 feet tall, as compared to 2.0 feet for* P. serotina.

* BARNETT, J. P., and MCLEMORE, B. F.
1961. TREE AGE UNIMPORTANT IN LONGLEAF SEED VIABILITY. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 135.
Seed from trees averaging 21, 40, and 85 years old did not differ in viability, either immediately or after 5 years of storage at 35° F.

* BEAUFAIT, W. R.
1957. COPPICE REGENERATION OF SWEETGUM. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 107.
A year after pulpwood-size sweetgums were cut flush with the ground, sprouts had adequately restocked the area.

———
1957. SIMPLE TOOL FOR PLANTING ACORNS. U. S. Forest Serv. Tree Planters' Notes 28, p. 5, illus.
A rod with a footplate to assure planting holes of uniform depth.

* BILAN, M. V.
1960. ROOT DEVELOPMENT OF LOBLOLLY PINE SEEDLINGS IN MODIFIED ENVIRONMENTS. Stephen F. Austin State Col. Forestry Dept. Bul. 4, 31 pp., illus.
Where the soil surface was shielded by mulch, shade, or sod, more than half the growth of roots was in the uppermost 3-inch layer, and more than 70 percent of root weight was in the top 6-inch layer. Scalping the site before seedlings were planted increased the total dry weight of roots and shoots greatly, increased temperature of the soil surface, and caused root systems to shift downward.

* BLAIR, R. M., and LANGLINAIS, M. J.
1960. NUTRIA AND SWAMP RABBITS DAMAGE BALDCYPRESS PLANTINGS. Jour. Forestry 58: 388-389, illus.
In some parts of Louisiana, depredations have been so severe that planting has been suspended.

* Bower, D. R., and Smith, J. L.
1961. PARTIAL GIRDLING MULTIPLIES SHORTLEAF CONES. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 132.
Cone production increased the third year after trees were partially girdled.

* ———— and Smith, J. L.
1961. PLANTING VS. SEEDING IN OUACHITAS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 131.
On unburned areas, planting resulted in more and better-distributed shortleaf pines per acre than did direct seeding. On burned plots, seeding yielded more trees.

Boyer, W. D.
1956. LAMBERT SEEDS LONGLEAF PINE. Ala. Lumberman 8(7): 12, 14, 16, illus.
Mr. Brooks Lambert, of the T. R. Miller Mill Company, direct-seeded a dry sandy ridge in southern Alabama after clearing off oaks and wiregrass with heavy machinery. The seed was coated with anthraquinone to repel birds.

* ————
1956. TIME OF LONGLEAF SEEDFALL. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 102.
In southern Alabama during 1955, an above-average longleaf seed crop totaled more than 100,000 viable seeds per acre, half of which fell between October 24 and November 7.

* ————
1958. LONGLEAF PINE SEED DISPERSAL IN SOUTH ALABAMA. Jour. Forestry 56: 265-268, illus.
The zone of seedfall generally accepted as adequate for natural regeneration (15,000 sound seeds per acre) extended only 1½ chains into clearcut openings even where more than 200,000 seeds per acre fell on the ground inside the stand bordering the clearcutting.

* Broadfoot, W. M.
1960. COTTONWOOD GROWTH VARIES WITH TYPE OF SOIL. Miss. Farm Res. 23(10): 7, illus. *Also as* Miss. Agr. Expt. Sta. Inform. Sheet 677, 2 pp., illus.
Trees on Robinsonville silt loam were 43 feet tall after 5 years in the field.

* Bruce, David.
1956. EFFECT OF DEFOLIATION ON GROWTH OF LONGLEAF PINE SEEDLINGS. Forest Sci. 2: 31-35, illus.
Seedlings were 30-, 60-, and 90-percent defoliated with shears in July, November, or February. Growth loss was about in proportion to the amount of foliage removed. Clipping in November reduced growth significantly more than July treatment, while defoliation in February was the least damaging.

* ————
1959. EFFECT OF LOW COMPETITION ON LONGLEAF PINE SEEDLING GROWTH. Soc. Amer. Foresters Proc. 1958: 151-153, illus.
Guides for deciding when reduction of competition is necessary to get longleaf to start height growth.

* Burns, R. M.
1959. DIRECT SEEDING OF PINES SHOWS PROMISE IN TEST. Miss. Farm Res. 22(10): 6, illus.
The seed was loblolly, treated with endrin and thiram. Unburned plots had a better seed catch but greater first-year mortality than burned plots.

* ————
1960. COPPER CARBONATE—BOON OR BANE? U. S. Forest Serv. Tree Planters' Notes 40, pp. 5-6.
This rabbit repellent should be applied to pine seedlings on the planting site, either by top-dipping or spraying. If used in the nursery, it is likely to damage seedlings when they are in bales.

* ————
1960. REPELLENTS REDUCE RABBIT DAMAGE. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 129.
See Burns, 1961, RABBIT REPELLENTS IN NORTH MISSISSIPPI.

* ————
1960. RESPONSE OF SELECTED CONIFEROUS SEEDS TO GIBBERELLIC ACID. U. S. Forest Serv. South. Forest Expt. Sta. South. Forest Res. 1: 13-16, illus.
At concentrations of about 100 milligrams per liter, gibberellic acid improved germination and height growth of loblolly pine. Germination of longleaf pine was not significantly affected, but the response of 150, 225, and 300 mg./liter was progressively greater. Effects on seeds of eastern redcedar were indeterminate.

* ————
1961. COLD-STORED HARDWOODS SURVIVE DELAYED PLANTING. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 131.
Seedlings of sweetgum and four species of red oak survived well after 3 months of cold storage in shipping bales.

* ————
1961. NO ADVANTAGE IN PLANTING HARDWOODS DEEP OR WITH MATTOCK. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 134.
On lowlands in north Mississippi, planting red oaks and sweetgum deep or with a mattock afforded no advantage over bar planting at rootcollar depth.

* ————
1961. RABBIT REPELLENTS IN NORTH MISSISSIPPI. U. S. Forest Serv. Tree Planters' Notes 45, pp. 19-22.
Repellents containing endrin, zinc dithiocarbamate, nicotine sulfate, and calcium polysulfide (lime-sulfur) were effective.

* ————
1961. SEED SOWING TOOL. U. S. Forest Serv. Tree Planters' Notes 45, pp. 3-4, illus.
A hand tool with a rake at the lower end for baring mineral soil. The hollow handle holds a day's supply of seeds and a metering device for dispensing them.

* Burton, J. D.
1961. GROWTH AND SURVIVAL IN TENNESSEE STRIP-MINE PLANTATIONS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 134.
Two-year survival and growth of planted loblolly, shortleaf, and Virginia pine were satisfactory on spoil banks, but white pine was disappointing.

Cassady, J. T.
1959. SEED REQUIREMENTS PER ACRE FOR DIRECT SEEDING. Direct Seeding in the South, 1959, a Symposium, pp. 120-128. Duke Univ.
Synopsizes information from southern foresters experienced in direct-seeding and concludes that "If I had to give a single, unqualified answer to the question of pine seed requirements for direct seeding it would be to sow 10,000 to 15,000 viable, repellent-treated seed per acre on almost any reasonable planting site for any of the major southern pines adapted to the area. Barring a major catastrophe . . . , such a rate should ensure 1,000 to 5,000 pine seedlings initially established per acre."

——— and Crowell, W. H.
1959. ROW SEEDING. Forest Farmer 18(5): 8, 12, 16, illus.
A machine for seeding pine in rows has been developed for cleared sites in the Florida sandhills. Row seeding requires less seed than broadcast methods and gives more even distribution.

* Croker, T. C., Jr.
1956. CAN THE SHELTERWOOD METHOD SUCCESSFULLY REGENERATE LONGLEAF PINE? Jour. Forestry 4: 258-260, illus.
In south Alabama and elsewhere, good stands of longleaf pine have been accidentally established by the release of advance reproduction. The circumstances resembled shelterwood cutting and suggest that this system may be a practical way of regenerating longleaf.

———
1956. LONGLEAF PINE SEEDLINGS DAMAGED WHEN SEED TREES ARE TRACTOR-LOGGED. Jour. Forestry 54: 401.
Though logging conditions were good, the stocking of longleaf seedlings in an Alabama forest was reduced from 83 to 76 percent, and many survivors were damaged. Those that had emerged from the grass were the most vulnerable.

* ———
1957. SCALPING AIDS LONGLEAF SEEDLING CATCH. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 112.
Scalping the seedbed just before seedfall more than doubled the catch of longleaf pine on a sandy site in southern Alabama.

* ———
1959. DIRECT SEEDING LONGLEAF PINE IN SOUTH ALABAMA AND NORTHWEST FLORIDA. Ala. Conserv. 30(5): 18-19, 27, illus.
In trials, good results were achieved with longleaf, slash, loblolly, and shortleaf pine, but not with sand pine. All seed was coated with Arasan to repel birds and with endrin to deter rodents.

———
1959. FURROW SEEDING—A NEW WAY TO REDUCE PINE REGENERATION COSTS. Ala. Forest Prod. 2(9): 108-109, illus.
See next entry.

* ———
1960. THE H-C FURROW SEEDER. U. S. Forest Serv. Tree Planters' Notes 43, pp. 15-16, illus.
This machine prepares a seedbed and sows pine in one operation, with only a tractor driver for a crew.

* Czabator, F. J.
1961. PLENTIFUL SEEDLINGS A FORESTRY RESEARCH SUCCESS. South. Lumberman 203(2537): 116-118, illus.
Advances in soil management and control of diseases and weeds enabled southern nurseries to raise their production from 0.5 million seedlings in 1924 to nearly 2.1 billion in 1960.

Davis, Broward.
1956. THE CHIPOLA CHIMNEY: A CONE KILN FOR RESEARCH USE. Jour. Forestry 54: 845-846, illus.
Instructions for making and using a small kiln developed at the Chipola Experimental Forest.

* Derr, H. J.
1955. BED DENSITY AFFECTS LONGLEAF VIGOR. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 97.
See next entry.

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1955. SEEDBED DENSITY AFFECTS LONGLEAF PINE SURVIVAL AND GROWTH. U. S. Forest Serv. Tree Planters' Notes 20, pp. 28-29.
Reducing nursery seedbed density from 30 to 10 seedlings per square foot improved survival and first-year growth of outplanted longleaf in Louisiana.

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1957. EFFECTS OF SITE TREATMENT, FERTILIZATION, AND BROWN-SPOT CONTROL ON PLANTED LONGLEAF PINE. Jour. Forestry 55: 364-367, illus.
In central Louisiana, burning, furrowing, or disking a 5-year-old grass rough had little effect on survival or early growth of planted longleaf pine. Spraying the seedlings with bordeaux mixture controlled the brown-spot needle blight and thereby enabled more than 75 percent of the surviving stand to start height growth in the fourth and fifth years. Fertilizing seedlings at planting time depressed growth by stimulating competing grasses except on furrowed strips where the grasses were completely eliminated.

———
1958. DIRECT SEEDING: A FAST, RELIABLE METHOD OF REGENERATING LONGLEAF PINE. U. S. Forest Serv. Tree Planters' Notes 32, pp. 15-20. *Also in* Tree Planters' Notes 33, pp. 20-25.
Recent developments.

* ———
1959. NEW RATES FOR REPELLANTS IN DIRECT SEEDING. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 123.
See second entry below.

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1959. TIME OF YEAR FOR DIRECT SEEDING. Direct Seeding in the South, 1959, a Symposium, pp. 114-118. Duke Univ.
February appears to be the best time for sowing loblolly, shortleaf, and possibly slash pine. Seed should be stratified and coated with repellents. Longleaf is sown unstratified, usually in late November or early December.

———
1959. WHAT'S NEW IN BIRD REPELLANTS FOR DIRECT SEEDING? Forests and People 9(4): 40, 44-45. *Also as* FAO Forestry Equipment Notes A. 25. 61, 2 pp. August 1961.
Lower dosages are now feasible for two of the three repellents used widely in seeding southern pines. Several new chemicals show promise.

* ———
1960. PREVENTING STICKER FAILURES IN DIRECT SEEDING. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 128.
Precautions for handling the latex and asphalt stickers commonly used to bond repellents to pine seed.

* ——— and Cossitt, F. M.
1955. LONGLEAF PINE DIRECT SEEDING. Jour. Forestry 53: 243-246, illus.
Experience during 1946-52.

* ——— and Mann, W. F., Jr.
1959. GUIDELINES FOR DIRECT-SEEDING LONGLEAF PINE. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 171, 22 pp., illus. *Reprinted in* Forest Farmer, 1960. Six parts. I.—19(4): 6-7, 15-17; II.—19(5): 16-20; III.—19(6): 28, 30, 32; IV.—19(8): 14-16; V.—19(9): 12-14, 16; VI.—19(10): 14-15, illus.
Summarizes knowledge on major aspects of longleaf seeding, from initial planning to management of the stand.

FARRAR, R. M., JR.
1959. SEEDED AND PLANTED PINES GROW AT SIMILAR RATES. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 122.
In south Alabama and west Florida, average height growth for the first two years in the field was 0.7 foot annually for seeded pines, and 0.79 foot for planted ones. Loblolly, slash, and shortleaf were represented.

* FASSNACHT, D. L.
1955. BAR-SLIT GOOD FOR SANDHILL HAND PLANTING. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 95.
In west Florida, longleaf and slash pine seedlings planted in slits made with a planting bar survived as well as those planted by hand in holes made with a post-hole digger.

* FERGUSON, E. R.
1957. CAUSES OF FIRST-YEAR MORTALITY OF PLANTED LOBLOLLY PINES IN EAST TEXAS. Soc. Amer. Foresters Proc. 1956: 89-92, illus.
In a dry summer growth and survival were best where competing vegetation had been eliminated or reduced before seedlings were planted. When soil moisture was more plentiful, site preparation had little effect. Pine reproduction weevils killed many seedlings on areas from which mature pines had recently been cut.

* ———
1959. WOOD TREATED WITH PENTA CAN DAMAGE PINE NURSERY SEEDLINGS. U. S. Forest Serv. Tree Planters' Notes 38, pp. 21-22.
If a preservative is needed for wood that will be close to freshly germinated southern pine seedlings, a good choice might be 0.2 percent metallic copper solution of copper naphthenate in diesel oil or one of the other lighter hydrocarbons.

* ——— and STEPHENSON, G. K.
1955. PINE REGENERATION PROBLEMS IN EAST TEXAS: A PROJECT ANALYSIS. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 144, 72 pp., illus.
Comprehensive review.

* GAMMAGE, J. L., and MAISENHELDER, L. C.
1960. REFRIGERATION PROLONGS VIABILITY OF COTTONWOOD SEED. U. S. Forest Serv. Tree Planters' Notes 43, pp. 5-6.
At 40°F. seed remained viable for 3 to 5 weeks; at room temperature it germinated poorly after 1 week.

* GRANO, C. X.
1957. INDICES TO POTENTIAL CONE PRODUCTION OF LOBLOLLY PINE. Jour. Forestry 55: 890-891, illus.
An 8-year study in southern Arkansas suggests that seed trees should be 12 inches or more in diameter, should have large, dense crowns, and should show evidence of having produced cones in the past.

* ———
1958. HOW TO RECOGNIZE GOOD SEED TREES. Forest Farmer 17 (4): 13, illus.
Pictoral summary. See also the entry immediately above.

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1958. TETRAZOLIUM CHLORIDE TO TEST LOBLOLLY PINE SEED VIABILITY. Forest Sci. 4: 50-53, illus.
Results agreed closely with those from sandflat checks. The chemical test is independent of seed dormancy but does not reveal the need for stratification nor measure germinative vigor. It yields results on short notice—48 hours or less—but is slower than sandflat tests in terms of the number of seeds that can be tested per man-hour.

* ———
1960. STRANGLING AND GIRDLING EFFECTS ON CONE PRODUCTION AND GROWTH OF LOBLOLLY PINE. Jour. Forestry 58: 897-898, illus.
Cone production was neither promoted nor hindered. Diameter and height growth were unimpaired. The test was on trees that were 3 to 15 inches in d.b.h. and that showed no sign of having borne cones previously.

* ———
1961. GERMINATION OF STRATIFIED LATEX-COATED LOBLOLLY PINE SEED AFTER SUBMERGENCE. Jour. Forestry 59: 452.
Submergence for 14 days had no deleterious effect.

* ———
1961. SHORTLEAF-LOBLOLLY REPRODUCTION LOSSES MODERATE, FOLLOWING SEED TREE FELLING. Jour. Forestry 59: 24-25, illus.
Seed trees numbered 22 per acre and were 10 to 33 inches in d.b.h. Their removal reduced from 84 to 70 percent the stocking of advanced reproduction, some of which was 19 years old.

* HARRINGTON, T. A.
1957. MAKING BIG IF'S SMALLER IN DIRECT SEEDING. South. Lumberman 195(2441): 129-130, illus.
On the Cumberland Pleateau of Tennessee, shortleaf and loblolly pine were successfully direct-seeded in a stand of low-grade oaks and hickories.

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1958. VIRGINIA PINE SEEDED IN TENNESSEE. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 114. *Also in* The Unit, News Letter 75, p. 30.
A good catch was obtained by sowing 15,000 seeds per acre in fire-plow furrows through a stand of upland hardwoods.

* ———
1959. PLANTED PINES SHOW MORE INITIAL HEIGHT GROWTH THAN SEEDED PINES. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 123.
On the Cumberland Plateau, loblolly and shortleaf pine nursery stock grew twice as tall the first year in outplanting as did direct-seeded pines.

* ———
1959. SEEDING SOUTHERN PINES ON THE CUMBERLAND PLATEAU. South. Lumberman 199(2489): 224.
Shortleaf, loblolly, and Virginia pine have been established by sowing repellent-treated seed in poorly stocked hardwood stands. First-year survival was better on sites prepared by disking or burning than on unprepared sites. March sowing produced fewer seedlings than December and January sowings.

* ———
1960. DIRECT SEEDING WHITE PINE. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 125.
In a stand of low-grade hardwoods in Tennessee, seed coated with Arasan-75 and endrin produced 2,350 white pine seedlings per acre after 1 growing season. Sowing was on disked ground.

* ———
1960. FROST HEAVING RUINS SPOIL-BANK SEEDING. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 128.
On a 1-year-old spoil bank in southern Tennessee, freezing and thawing of the soil uprooted 94 percent of an initially successful seeding of shortleaf pine.

* ———
1960. STRATIFYING REPELLENT-TREATED PINE SEED. U. S. Forest Serv. Tree Planters' Notes 42, p. 5.

Germinative capacity of loblolly, shortleaf, and Virginia pine may be seriously reduced if fresh seed is repellent-coated and then stratified. Cold storage for a few months may largely forestall damage from later repellent treatment and stratification.

* HATCHELL, G. E.
1961. A LOOK AT 9-YEAR-OLD SEEDED LOBLOLLY PINE. Forests and People 11(3): 25, 44-45, illus.
The pines have expressed dominance without evidence of stagnation. Dominants are growing nearly as fast as in planted stands. Disking for seedbed preparation appears to have stimulated early growth.

* HEBB, E. A.
1955. OPERATION SANDHILLS—TWO YEARS LATER. South. Lumberman 191(2393): 159-160, illus.
Two years after being planted on the sandhills of western Florida, slash pine has better survival, growth, and form than loblolly, shortleaf, longleaf, or Monterey pine.

———
1955. SEEDFALL AND CUTTING SYSTEMS IN TEXAS SHORTLEAF STANDS. Jour. Forestry 53: 846-847.
In a good seed year, seedfall varied greatly on areas cut by different systems. Fifty-nine percent of the seed fell in November and 25 percent in December.

* ———
1955. SLASH PINE—PROMISING SANDHILLS SPECIES. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 100.
Two years after being planted on carefully prepared sites in west Florida, slash pine seedlings averaged nearly 2 feet tall.

HOPKINS, WALT.
1957. AN EYE TO THE FUTURE. Gulf Coast Cattleman 23(3): 15-16, illus.
A private company has established 11,500 acres of slash pine plantations in western Florida, some of them on sandhill lands.

HUCKENPAHLER, B. J.
1955. AUXINS FAIL TO STIMULATE ROOTING OF YELLOW-POPLAR CUTTINGS. Bot. Gaz. 117: 73-75.
Indolebutyric acid, indoleacetic acid, and naphthalene-acetic acid were applied in a variety of concentrations and immersion periods to cuttings made at several seasons from wood of different ages.

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1957. WANTED: A METHOD OF ROOTING YELLOW-POPLAR CUTTINGS. Jour. Forestry 55: 425.
See preceding entry.

* JOHNSON, R. L.
1958. CLIP OR DEEP-PLANT CYPRESS? U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 116.
Treatments to reduce transpiration did not improve survival and early growth of baldcypress seedlings planted in the Mississippi Delta.

* ——— and BURKHARDT, E. C.
1961. COTTONWOOD SEEDS-IN ON BULLDOZED STRIPS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 135.
In a cutover hardwood stand cottonwood was regenerated naturally by removing the overstory and then cutting shallow trenches with a bulldozer.

KALOYEREAS, S. A., MANN, W. F., JR., and MILLER, J. C.
1961. EXPERIMENTS IN PRESERVING AND REVITALIZING PINE, ONION, AND OKRA SEEDS. Econ. Bot. 15: 213-217, illus.
Longleaf seed must be dried to 10 percent or less if stored at temperatures near or below freezing. Drying to 5 or 6 percent, however, impaired viability. Carbon dioxide placed in sealed containers with seeds seemed to improve germinability after storage, but carbon dioxide plus ethylene oxide was not beneficial.

KOSHI, P. T.
1960. DEEP PLANTING HAS LITTLE EFFECT IN A WET YEAR. U. S. Forest Serv. Tree Planters' Notes 40, p. 7.
Undersized slash and loblolly seedlings were planted in a Texas field with a stand of Bermuda grass and weeds. In a dry season, deep planting might have improved survival, but in 1957 the only differences were those related to morphological grade of the stock.

KRINARD, R. M.
1959. NO ADVANTAGE TO CLIPPING BALDCYPRESS PLANTING STOCK. U. S. Forest Serv. Tree Planters' Notes 36, p. 14.
Clipping or deep planting did not improve either the survival or growth of seedlings planted in heavy clay.

* MCCLURKIN, D. C.
1960. LEGUMES FAIL TO BENEFIT LOBLOLLY PINE PLANTINGS IN NORTH MISSISSIPPI. U. S. Forest Serv. Tree Planters' Notes 43, pp. 11-12.
The legumes, Lespedeza bicolor, L. sericea, *and* Trifolium incarnatum, *were seeded among newly planted pine seedlings. Sites were gullied or severely sheet-eroded.*

* MCKNIGHT, J. S., and MAISENHELDER, L. C.
1960. CHANGE TO QUICK TREES. South. Lumberman 201 (2511): 30-31, illus. *Also in* U. S. Forest Serv. Tree Planters' Notes 51, pp. 23-24, illus. April 1962. *Also in* Forest Farmer 21(13): 12, illus. 1962.
On suitable sites and with cultivation during the first year, cottonwood plantings make remarkable growth.

* MCLEMORE, B. F.
1959. CONE MATURITY AFFECTS GERMINATION OF LONGLEAF PINE SEED. Jour. Forestry 57: 648-650.
Germination was best when cones were picked just as they were opening on the trees.

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1960. SMALL, FAST-DRYING CONE KILN. Forest Farmer 19(13): 10-11, 15, illus. *Also in* U. S. Forest Serv. Tree Planters' Notes 47, pp. 9-12, illus. 1961.
Construction details of a gas-fired kiln that will dry 28 bushels of pine cones in 48 hours.

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1961. ESTIMATING PINE SEED YIELDS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 134.
Formulae for predicting yield of seeds from the number of full seeds exposed when longleaf, slash, and loblolly cones are sliced longitudinally.

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1961. HILA OF FULL AND EMPTY LONGLEAF PINE SEEDS ARE DISTINGUISHABLE. Forest Sci. 7: 246, illus.
Pinus palustris *seeds with prominent hila are full; those with faint scars are empty.*

———
1961. PROLONGED STORAGE OF LONGLEAF CONES WEAKENS SEED. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 132.
If the seed is to be stored, cones should not be held in burlap bags for more than 30 days between collection and extraction.

* McLemore, B. F.
1961. STORAGE OF LONGLEAF PINE SEED. U. S. Forest Serv. Tree Planters' Notes 47, pp. 15-19, illus.
If its moisture content is held to 10 percent or less, longleaf seed can be stored at least 5 years at temperatures of 34° F. or below.

* ———— and Czabator, F. J.
1961. LENGTH OF STRATIFICATION AND GERMINATION OF LOBLOLLY PINE SEED. Jour. Forestry 59: 267-269, illus.
Germination tests of seed stratified 0, 15, 30, 45, and 60 days were evaluated by computing germination values (GV), which combine germinative energy and capacity. Increases in length of stratification usually increased GV; the greatest increase occurred between 0 and 15 days and the smallest between 45 and 60 days.

* McReynolds, R. D.
1960. MORTALITY OF NEWLY GERMINATED SOUTHERN PINE SEEDLINGS FOLLOWING INUNDATION. U. S. Forest Serv. Tree Planters' Notes 43, pp. 23-25.
At ages of 25 days from seed, most loblolly and slash pine seedlings survived 20 days of flooding, but shortleaf and longleaf died after 12 days. Summer flooding was more damaging than spring flooding.

* Maisenhelder, L. C.
1956. COST OF PLANTING COTTONWOOD. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 106.
Site preparation, planting, and plantation care for one season cost $18 per acre on pasture land and $32 on wooded areas.

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1957. PROPAGATION OF SOME DELTA HARDWOODS BY ROOTING. Fourth South. Forest Tree Impr. Conf. Proc. 1957: 55-58.
Cottonwood and black willow have rooted satisfactorily both in the nursery and in plantations. Sycamore and green ash have done well in nursery tests. The oaks will require more intensive testing. Sweetgum is the only species tested that has failed to produce some rooting.

* ————
1957. TIPS FOR PLANTING SOUTHERN HARDWOODS. South. Lumberman 195(2441): 93-94, illus.
Though there are yet few satisfactory commercial plantations in the South, successful ones can be established if planting is restricted to the better soils, if the species are suited to the site, and if competing vegetation is kept down until the trees are well established.

* ————
1958. NATURAL REGENERATION FOLLOWING SELECTION CUTTING IN BOTTOMLAND HARDWOODS. La. State Univ. Seventh Ann. Forestry Symposium Proc. 1958: 21-25.
Unless abused, most bottom-land forests reproduce satisfactorily under a system of selective cutting. Fire must be eliminated and grazing controlled. Heavy masses of ground cover will interfere with regeneration, but briars and weeds, if not too dense, act as a nurse crop.

* ————
1960. COTTONWOOD PLANTATIONS FOR SOUTHERN BOTTOM LANDS. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 179, 24 pp., illus.
Establishing and cultivating plantations. Estimated costs and returns.

* Mann, W. F., Jr.
1956. DIRECT-SEEDING THE SOUTHERN PINES. U. S. Forest Serv. Tree Planters' Notes 25, pp. 12-19, illus.
Summarizes recommendations for longleaf pine, and reports progress with loblolly and slash.

* ————
1957. DIRECT-SEEDING THE SOUTHERN PINES. Forest Farmer 17(2): 8-9, 12, 16-18, illus. *Also in* Forestry Newsletter, Southeast. Sect. Soc. Amer. Foresters 13(2): 10-15. *Also in* Forest Farmer (Sixth Manual ed.) 17(7): 73-75, illus. 1958. *Also in* (Seventh Manual ed.) 18(8): 72-75, illus. 1959. *Also in* (Eighth Manual ed.) 19(7): 87-90, illus. 1960. *Also in* (Ninth Manual ed.) 20(7): 58-61, illus. 1961.
Methods for seeding longleaf, loblolly, and slash pine.

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1958. GUIDES FOR DIRECT SEEDING THE SOUTHERN PINES. Forests and People 8(3): 16-17, 44, 47-48, 51-52, illus.
Longleaf, loblolly, and slash pine.

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1958. OUR CURRENT RESEARCH NEEDS: SEEDING AND PLANTING. Forest Farmer 18(2): 12-13, illus.
Especially needed is information on the regeneration of hardwoods, on seed dormancy and other aspects of seed storage, on means of reducing losses from predators and parasites, and on methods of correlating direct-seeding techniques with natural seedfall.

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1959. INDUSTRY TESTS LOBLOLLY DIRECT SEEDING. Forests and People 9(1): 22-23, 30-32, illus.
Results from 18 separate seedings on a total of 5,900 acres.

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1959. PREPARING SEED FOR DIRECT SEEDING. Direct Seeding in the South, 1959, a Symposium, pp. 52-59. Duke Univ.
Cold stratification, to speed germination, and repellent coating of seed, to ward off predators, are two of the most critical jobs confronting the direct seeder.

* ————
1961. DIRECT SEEDING COMES TO THE SOUTH. Soc. Amer. Foresters Proc. 1960: 15-18, illus.
Summarizes the development, at Alexandria, Louisiana, of a method for seeding longleaf and other southern pines, reviews evidence that the technique is finding wide use, and describes a large commercial seeding.

* ———— and Burkhalter, H. D.
1961. THE SOUTH'S LARGEST SUCCESSFUL DIRECT-SEEDING. Jour. Forestry 59: 83-87, illus.
An industrial firm has direct-seeded 18,545 acres of cutover longleaf land. Direct costs were less than half of what would have been required for planting, capital outlay and manpower requirements were smaller, and supervision was simpler.

———— and Derr, H. J.
1955. NOT FOR THE BIRDS. Forests and People 5(3): 32-33, illus. *Also in* U. S. Forest Serv. Tree Planters' Notes 20, pp. 3-6, illus.
Morkit, a commercial bird repellent, has given excellent results on longleaf seed in Louisiana.

———— and Derr, H. J.
1956. DIRECT SEEDING OF LONGLEAF PINE. Forest Farmer 15(6): 4-6, 18, illus.
Techniques, including use of Morkit as a bird repellent.

———— and Derr, H J.
1958. REGENERATION OF UNDERSTOCKED LONGLEAF STANDS . . . SKILL NOT LUCK! Forests and People 8(2): 20-21, 53, illus.

A 250-acre area with a partial seed source was regenerated with natural seedfall supplemented by direct seeding. Gives a schedule for regenerating understocked. second-growth longleaf stands.

* ———— and DERR, H J.
1961. GUIDELINES FOR DIRECT-SEEDING LOBLOLLY PINE. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 188, 23 pp., illus.
Site evaluation and preparation, seed procurement and treatment, methods and rate of sowing, seedling inventories, costs.

* ———— DERR, H. J., and MEANLEY, BROOKE.
1955. A BIRD REPELLENT FOR LONGLEAF SEEDING. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 99.
See next entry.

* ———— DERR, H. J., and MEANLEY, BROOKE.
1956. A BIRD REPELLENT FOR DIRECT SEEDING OF LONGLEAF PINE. Jour. Forestry 54: 190-191.
Morkit has given excellent results in central Louisiana.

———— DERR, H. J., and MEANLEY, BROOKE.
1956. BIRD REPELLENTS FOR DIRECT SEEDING LONGLEAF PINE. Forests and People 6(3): 16-17, 48.
Morkit has been withdrawn from the U. S. market, but several other preparations are likely to be acceptable replacements. One of these is Arasan.

———— and KINGSLEY, C. E.
1958. BIRD CONTROL IN FOREST NURSERIES. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 113.
Bird depredations in southern pine nurseries can be stopped with repellents developed for direct seeding.

* ———— and RUSSELL, T. E.
1956. RINGING STIMULATES LONGLEAF CONE PRODUCTION. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 103.
See next entry.

———— and RUSSELL, T. E.
1957. LONGLEAF CONE PRODUCTION DOUBLED BY RINGING. U. S. Forest Serv. Tree Planters' Notes 28, pp. 6-7, illus.
Two half-circles were cut through the cambium on opposite sides of the bole, slightly above stump height. Trees smaller than 10 inches in d.b.h. did not respond, probably because they were too small to bear cones abundantly.

* MAPLE, W. R.
1960. LOBLOLLY FOR THE ARKANSAS OZARKS? U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 126.
Vigorous growth of plantations indicates that loblolly may be suitable for short rotations, even though it is not native.

* ————
1961. FOREST TREES FOR THE ARKANSAS OZARKS. Ark. Farm Res. 10(5): 7.
Shortleaf pine remains the preferred species for planting. Loblolly and Virginia pine are possible alternatives for short rotations. Hardwood planting has not been consistently successful.

* ————
1961. TREATED SHORTLEAF PINE SEED CAN BE STORED. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 136. *Also in* Amer. Tree Farmer and Forestry Digest, Jan.-Feb. 1962, p. 5.
Seed that has been stratified and coated with repellents for direct seeding may be stored for several months.

MEANLEY, BROOKE, and BLAIR, R. M.
1957. DAMAGE TO LONGLEAF PINE SEEDLINGS BY COTTON RATS. Jour. Forestry 55: 35.
Recent attacks in central Louisiana are a reminder that this rodent can severely damage young pines when it finds a favorable habitat. It seems partial to longleaf but attacks other species.

———— MANN, W. F., JR., and DERR, H. J.
1956. COTTON RATS DAMAGE LONGLEAF SEEDLINGS. Forests and People 6(4): 42-43, illus.
See preceding entry.

————MANN, W. F., JR., and DERR, H. J.
1956. NEW BIRD REPELLENTS FOR LONGLEAF SEED. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 105. *Also in* The Unit, News Letter 66, p. 11. *Also in* U. S. Forest Serv. Tree Planters' Notes 28, p. 8. 1957.
The bird-repellent Morkit has been withdrawn from the U. S. market, but several other chemicals are good substitutes.

* MIGNERY, A. L., and YEATMAN, H. C.
1960. MICE HINDER PINE SEEDING ON CUMBERLAND PLATEAU. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 129.
A thiram-endrin coating repelled white-footed mice from seeds of loblolly, Virginia, and shortleaf pine.

MUNTZ, H. H.
1961. RECENT ADVANCES IN PLANTING AND DIRECT SEEDING. *In* Advances in Management of Southern Pine. La. State Univ. Tenth Ann. Forestry Symposium Proc. 1961: 34-39.
Brief review.

NEELANDS, R. W.
1961. HOW TO MAKE INSTANT TREES! Forests and People 11(4): 28-29, illus. *Also in* Forest World, pp. 30-31. June 1962.
Two years after being planted as cuttings, cottonwoods on silt loam near Greenville, Mississippi, averaged 22 feet tall and 3.5 inches in diameter.

* RUSSELL, T. E.
1958. SPACING—ITS ROLE IN THE GROWTH OF PLANTED SLASH PINE. South. Lumberman 197(2465): 115-117, illus.
" . . . Spacing of 6 by 8 feet—908 trees per acre—will, when initial survival is 80 percent or better, meet the objectives of providing not only satisfactory early volume and diameter growth, but also sufficient stocking to sustain losses to disease and storms. Wider spacings, such as 8 by 8 feet, probably will not."

————
1958. THE DIRECT SEEDING OF SOUTHERN PINES. Amer. Pulpwood Assoc. Tech. Paper 58-P26, 8 pp., illus.
Recommendations for longleaf, loblolly, and slash pines.

SCARBROUGH, N. M., and ALLEN, R. M.
1954. BETTER LONGLEAF SEEDLINGS FROM LOW-DENSITY NURSERY BEDS. U. S. Forest Serv. Tree Planters' Notes 18, pp. 29-32.
Stock from beds with not more than about 24 seedlings per square foot survived better in the field and began height growth sooner than seedlings from denser beds.

* SCHEER, R. L.
1957. SAND PINE—SCRUB OR TIMBER TREE? South. Lumberman 195(2441): 191-193, illus.
In the deep sands of west Florida, sand pine has outgrown other southern pines (notably slash) on cleared sites and has been the only pine able to compete with undisturbed oaks and wiregrass. First-year survival, however, has been poor.

* SCHEER, R. L.
1959. COMPARISON OF PINE SPECIES ON FLORIDA SANDHILLS. Jour. Forestry 57: 416-419, illus.
So far, slash pine has performed better than loblolly, shortleaf, and longleaf. Monterey pine has been a total failure.

* _____ and HODGES, J. D.
1960. PLANTED SAND PINE GROWS WELL ON UNPREPARED FLORIDA SANDHILLS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forest Res. 1: 7-8, illus.
Sand pine grew well in competition with wiregrass and small oaks; other species of southern pines required release.

SCHOENIKE, R. E.
1955. WHY PINE SEED CROPS FAIL. Forest Farmer 14(10): 10.
In March 1955, loblolly and shortleaf pines near Crossett, Arkansas, bore abundant flowers, but heavy rains washed the loblolly pollen out of the air, and a late freeze ruined the shortleaf flowers.

* SCHOMAKER, C. E.
1956. LOBLOLLY PINE SUCCEEDS ON SPOIL BANKS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 102.
The spoil banks were in north Alabama.

* _____
1957. TOPOGRAPHY AND YELLOW-POPLAR GROWTH. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 107.
Two-year results; see Smalley, 1961.

* _____
1958. TWO-YEAR RESULTS OF PLANTING YELLOW-POPLAR IN NORTH ALABAMA. Jour. Forestry 56: 37-38, illus.
For 5-year results, see Smalley, 1961.

* SHOULDERS, EUGENE.
1959. CAUTION NEEDED IN FALL APPLICATIONS OF NITROGEN TO NURSERY STOCK. U. S. Forest Serv. Tree Planters' Notes 38, pp. 25-27.
"This study further demonstrates the folly of prescribing fertilization without adequate knowledge of the needs of the plant at the particular time the fertilizer is to be available, and the extent to which these needs will be supplied by nutrients already in the soil."

* _____
1959. ROOT PRUNING BOOSTS LONGLEAF SURVIVAL. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 120.
See next entry.

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1959. ROOT PRUNING BOOSTS LONGLEAF SURVIVAL. U. S. Forest Serv. Tree Planters' Notes 36, pp. 15-19, illus.
Recommends that pruning be done at a depth of approximately 7 inches and 2 or 3 months before the seedlings are lifted from the nursery bed.

* _____
1960. SEEDBED DENSITY INFLUENCES PRODUCTION AND SURVIVAL OF LOBLOLLY AND SLASH PINE NURSERY STOCK. U. S. Forest Serv. Tree Planters' Notes 42, pp. 19-21.
See second entry below.

* _____
1960. SHOULD PINES BE ROOT-PRUNED IN NURSERY BEDS? U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 127.
In contrast to results elsewhere, root pruning in a nursery near Pollock, Louisiana, did not check unwanted late-season height growth of longleaf, loblolly, and slash pine.

* _____
1961. EFFECT OF NURSERY BED DENSITY ON LOBLOLLY AND SLASH PINE SEEDLINGS. Jour. Forestry 59: 576-579, illus.
For both species, densities of about 40 seedlings per square foot at lifting time were better than densities of 10, 20, and 30 in terms of seedlings that were able to establish themselves in the field. Lowering density below 40 improved morphological quality and, in a droughty year, field survival also.

* _____
1961. EFFECT OF SEED SIZE ON GERMINATION, GROWTH, AND SURVIVAL OF SLASH PINE. Jour. Forestry 59: 363-365.
Small seeds yielded smaller seedlings and fewer of plantable grade than medium and large seeds, but growth during the first year in the field eliminated much of the height difference present in the nursery. Nursery germination and field survival were not related to seed size.

* SIEGEL, W. C.
1961. CONTRACT MACHINE PLANTING FAVORED. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 133.
On loblolly pine land in northwest Louisiana, the typical plantation is machine-planted by a contractor at a spacing of 6 by 8 feet.

* _____
1961. INITIAL SURVIVAL OF LOBLOLLY PLANTATIONS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 132.
In private plantations about Shreveport, Louisiana, first-year survival was better under hardwoods than in the open, and better for hand planting than for machine planting. Nearly all plantations received some release

* SMALLEY, G. W.
1961. IN NORTH ALABAMA, TOPOGRAPHIC POSITION IS KEY TO YELLOW-POPLAR SITES. Forest Farmer 20(12): 14, 16, illus.
During 5 years, planted yellow-poplars have grown best in bottoms and on middle and lower north slopes, less rapidly on upper north and middle south slopes, and poorly on upper south slopes.

* _____
1961. LOBLOLLY UNRESPONSIVE TO FERTILIZER IN ALABAMA TEST. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 132.
Fertilizing with 200 to 600 pounds N per acre failed to stimulate height growth of a 4-year-old plantation.

* SMITH, J. L., BOWER, D R., and BLOCKER, W. W.
1961. SEEDLING MORTALITY IN OUACHITAS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 134.
Mortality of natural shortleaf pine reproduction varies with aspect, cover, and depth of soil.

SMITH, L. F.
1955. DEVELOPMENT OF LONGLEAF PINE SEEDLINGS NEAR LARGE TREES. Jour. Forestry 53: 289-290.
Although earlier removal is preferable large pines and oaks may be left for 5 or 6 years without serious mortality among the pine reproduction. See also second entry below.

* _____
1960. EARLY GROWTH OF SLASH PINE ON UPLAND AND WET SITES. Jour. Forestry 58: 720-725, illus.
In plantations in south Mississippi, height growth was considerably greater on uplands than in bottom lands. Growth began between March 1 and 15 each year; it continued about 152 days but was 90 percent complete by July 1.

* _____
1961. GROWTH OF LONGLEAF PINE SEEDLINGS UNDER LARGE PINES AND OAKS IN MISSISSIPPI. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 189, 4 pp., illus.

When brown-spot needle blight was controlled, longleaf seedlings survived and started height growth near large pines and oaks. Oaks were severer competitors than pines. See second entry above.

* _____

1961. RAPID GROWTH OF SLASH AND LOBLOLLY PINES ON CULTIVATED PLOTS. U. S. Forest Serv. Tree Planters' Notes 46, pp. 9-10, illus.

Slash pines averaged 13.0 feet tall and loblolly pines 14.2 feet after 4 years in a cultivated plantation in southern Mississippi. Fertilizer did not speed growth.

* _____

1961. TREE PERCENT ON BURNED AND UNBURNED LONGLEAF SEEDBEDS. Jour. Forestry 59: 201-203, illus.

Seedling establishment in south Mississippi was markedly aided by a preseedfall burn to eliminate the ground cover of grass and needles. The study also yielded data on distribution of seedfall and seedlings.

* SNOW, G. A., and ALLEN, R. M.

1961. DAMAGE TO PINE SEEDLINGS BY SANTOMERSE SX. U. S. Forest Serv. Tree Planters' Notes 45, pp. 25-26, illus.

When used at rates somewhat greater than are common in the South, this surfactant stunted nursery seedlings of slash, loblolly, and shortleaf pine.

* STRANSKY, J. J.

1960. LET PLOWED GROUND SETTLE BEFORE PLANTING PINES. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 128.

In east Texas, loblolly pines were planted in mid-January on undisturbed soil, on fresh furrows, and on ground deeply plowed and disked the preceding October. Fall rains were light, and by January the plowed sites were drier than the others. The dryness probably reduced pine survival.

* THAMES, J. L.

1961. EFFECTS OF WAX COATINGS ON LEAF TEMPERATURES AND FIELD SURVIVAL OF PINUS TAEDA SEEDLINGS. Plant Physiol. 36: 180-182, illus

Wax transpiration retardant reduced survival of seedlings planted on a sandy soil in Mississippi. Under radiant heat in the laboratory, temperature of waxed leaves rose 4.4° F. above that of normal leaves.

* URSIC, S. J.

1956. BALE STORAGE EFFECTIVE FOR LOBLOLLY PINE SEEDLINGS. Jour. Forestry 54: 815-816, illus.

In north Mississippi, loblolly pine seedlings can be successfully stored in standard Forest Service bales for periods up to 5 weeks. Such storage is more convenient and cheaper than conventional heeling-in.

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1956. BALE STORAGE OF LOBLOLLY SEEDLINGS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 103.

See preceding entry.

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1956. LATE WINTER PRELIFTING FERTILIZATION OF LOBLOLLY SEEDBEDS. U. S. Forest Serv. Tree Planters' Notes 26, pp. 11-13.

Fertilizer decreased first-year survival of seedlings planted on adverse sites in north Mississippi, and did not benefit vigor and height growth.

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1959. SITES AND SEEDLING GRADES INFLUENCE LOBLOLLY GROWTH. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 122.

Seedlings planted on a ridge in north Mississippi, under a deadened overstory of hardwoods, made better early height growth than those planted on eroded old fields. Planting stock with stems averaging 7 inches long grew faster than stock with 5-inch stems.

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1960. WHAT'S YOUR SURVIVAL? U. S. Forest Serv. Tree Planters' Notes 40, pp. 3-4.

Techniques for sampling first-year survival of pine plantations at minimum cost and effort.

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1961. FIRST YEAR CRITICAL FOR LOBLOLLY ON ERODED LANDS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 136.

Three-fourths of the mortality occurred in the first year. The test was in north Mississippi.

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1961. LETHAL ROOT TEMPERATURES OF 1-0 LOBLOLLY PINE SEEDLINGS. U. S. Forest Serv. Tree Planters' Notes 47, pp. 25-28, illus.

Seedlings survived outplanting after their roots had been immersed for 5 minutes in water heated to 48° C. Longer immersions or higher temperatures caused mortality. Baled seedlings survived slightly higher temperatures, but indications were that stock is not worth planting if heated to more than 50° C.

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1961. PIT STORAGE OF BALED LOBLOLLY SEEDLINGS. U. S. Forest Serv. Tree Planters' Notes 45, pp. 13-14. *Also in* Miss. Farm Res. 23(11): 2, illus. 1960.

In north Mississippi, baled loblolly pine planting stock has been stored for 6 weeks in earth pits.

* _____

1961. TOLERANCE OF LOBLOLLY PINE SEEDLINGS TO SOIL MOISTURE STRESS. Ecol. 42: 823-825, illus.

In pots of light- to medium-textured soils, loblolly pine and little bluestem grass survived at the ultimate wilting point of the sunflower when needle moisture content dropped to 80 percent; pines failed to recover when watered.

WAKELEY P. C.

1957. A GUIDE TO THE PLANTING OF SOUTHERN PINES. Forest Farmer 17(1): 10-11, illus. *Also in* Forest Farmer (Sixth Manual ed.) 17(7): 80-81, illus. 1958. *Also in* (Seventh Manual ed.) 18(8): 78-79, illus. 1959. *Also in* (Eighth Manual ed.) 19(7): 85-86, illus. 1960.

Planting policies and plans, cone collection, plantation establishment and care.

* _____ and CAMPBELL, T. E.

1960. SEEDLESS LONGLEAF CONES CAN MATURE AND OPEN. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 127.

An artificially pollinated flower produced a cone with no seeds, either filled or empty.

_____ and MANN, W. F., JR.

1957. REGENERATION—WHEN, WHY, AND HOW. First tech. session, Gulf States Sect. Soc. Amer. Foresters Proc. 1957: 12-18.

"We . . . predict that, even after the greater part of the South's currently idle acreage has been planted, artificial regeneration will level off at a higher rate per year than has hitherto been assumed. It will do so for two reasons. One is that artificial regeneration will be increasingly preferable to waiting for natural reproduction. The other is that, increasingly as time goes on, planting or direct seeding will enable us to replace nature's casual mixture of good, poor, and indifferent trees with uniformly better ones."

WALKER, L. C., and DAVIS, V. B.
1956. SEED TREES RETARD LONGLEAF PINE SEEDLINGS. Jour. Forestry 54: 269, illus.
Longleaf seed trees in southern Alabama reduced survival and vigor of seedlings well beyond the spread of the tree crowns. Thus some other factor, probably root competition, limits longleaf seedling growth more than shading does.

* WILLISTON, H. L.
1955. FIFTH-YEAR RESULTS OF HARDWOOD SPECIES ADAPTABILITY STUDIES. Papers Presented Forestry Dept. Sect. Meet., 1955 Ann. Res. Conf., Miss. Agr. Expt. Sta., pp. 3-9.
Loblolly pine seems best for underplanting depleted stands of upland hardwoods in north Mississippi. White ash survived well and is worth further trials on minor bottoms and lower slopes. Yellow-poplar has possibilities, but suffered considerable mortality from a canker.

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1959. INUNDATION DAMAGE TO LOBLOLLY PINE SEEDLINGS. U. S. Forest Serv. Tree Planters' Notes 36, p. 13.
Seedlings survived 15 days of complete submergence during both dormant and growing seasons.

* ——— and HUCKENPAHLER, B. J.
1957. HARDWOOD UNDERPLANTING IN NORTH MISSISSIPPI. Jour. Forestry 55: 287-290.
Of 6 species tested in the Brown Loam hills, loblolly pine had best survival and growth. White ash thrived on moist sites when it was not browsed by deer, and yellow-poplar would probably have succeeded if it had not been attacked by a canker. Black locust plantings were ruined by borers. Black walnut, when released, grew well in isolated spots on minor bottoms. White oak grew very slowly.

WOODS, F. W.
1959. SLASH PINE ROOTS START GROWTH SOON AFTER PLANTING. Jour. Forestry 57: 209, illus.
In west Florida, slash pine seedlings planted in February initiated root growth earlier than longleaf and sand pine.

* ———
1960. GIBBERELLIC ACID FAILS TO STIMULATE GROWTH OF LONGLEAF PINE SEEDLINGS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forest Res. 1: 17.
Concentrations ranged from 100 to 1000 ppm in water or oil sprays; 0.5 and 1.0 percent GA in lanolin emulsion was also applied in warm drops on the terminal buds.

——— HEBB, E. A., and FASSNACHT, D. L.
1956. MULCH NOT BENEFICIAL TO SEEDLINGS ON DEEP SANDS. Jour. Forestry 54: 595.
In western Florida, a mulch of longleaf pine needles did not increase the survival of pines planted in the sandhills, and seems to have promoted excessive temperatures around the young stems.

YEATMAN, H. C.
1960. POPULATION STUDIES OF SEED-EATING MAMMALS. Jour. Tenn. Acad. Sci. 35(1): 32-48, illus.
Traps on the Cumberland Plateau of Tennessee captured the white-footed mouse, Bachman's shrew, short-tailed shrew, and lesser short-tailed shrew. The last-named species is a new record for the area. White-footed mice may be troublesome where direct-seeding of pine is attempted, but seem to be repelled by seed coatings of Arasan and endrin.

* YOCOM, H. A.
1955. CAREFUL LOGGING CAUSES LITTLE DAMAGE. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 96.
In upland pine-hardwood stands near Birmingham, Alabama, pine reproduction was not seriously diminished by tree-length logging with a small crawler tractor.

* ZAHNER, ROBERT.
1959. FERTILIZER TRIALS WITH LOBLOLLY PINE IN SOUTHERN ARKANSAS. Jour. Forestry 57: 812-816, illus.
A single fertilization with nitrogen stimulated diameter growth for two years, but did not affect height growth. The addition of phosphorus, potassium, or minor elements did not increase growth more than did nitrogen alone. Total 5-year diameter growth increase attributable to fertilization was about 10 percent for a single application of 100 pounds of nitrogen per acre.

GENETICS

* ALLEN, R. M.
1960. CHANGES IN ACID GROWTH SUBSTANCES IN TERMINAL BUDS OF LONGLEAF PINE SAPLINGS DURING THE BREAKING OF WINTER DORMANCY. Physiologia Plant. 13: 555-558, illus.
Greatest changes were an increase in a promoter that chromatographs similarly to indoleacetic acid in isopropanol:ammonia:water and decrease of an inhibitor found at Rf 0.6-0.7 with the same solvent.

———
1960. POLE STEPS FOR CLIMBING TREES. Jour. Forestry 58: 563.
Telephone pole steps are useful on trees that are climbed repeatedly or are so far from roads that ladders must be carried considerable distances.

* ——— and SCARBROUGH, N. M.
1961. FERTILIZER AND MULCH AID GRAFTING OF SLASH PINE. Jour. Forestry 59: 294.
Number of successful unions was more than doubled by fertilizer and tripled by a combination of fertilizer and pine needle mulch.

* CAMPBELL, T. E., and WAKELEY, P. C.
1961. POSSIBLE REFINEMENTS IN CONTROLLED POLLINATION OF SOUTHERN PINES. South. Forest Tree Impr. Conf. Proc. 6: 121-128.
Itemizes the "Placerville" stages of longleaf pine flowers for bagging, pollination, and debagging to attain certain degrees of seed set and freedom from contamination, and evaluates laboratory germination of pollen in terms of fertilizing ability.

* DERR, H. J., and DELL, T. R.
1960. WHERE SHOULD WE GET SLASH PINE SEED FOR LOUISIANA? Forests and People 10(2): 30-31, illus.
A plantation in central Louisiana contains slash pines from seed collected in South Carolina, Florida, and Georgia, as well as from southern Mississippi and eastern Louisiana. At age 22 years, trees from the various sources do not differ significantly in volume, size, or amount of cankering from southern fusiform rust

* ———— and ENGHARDT, HANS.
1960. IS GEOGRAPHIC SEED SOURCE OF SLASH PINE IMPORTANT? South. Lumberman 201(2513): 95-96, illus.
See preceding entry.

* DUFFIELD, J. W., and SNYDER, E. B.
1958. BENEFITS FROM HYBRIDIZING AMERICAN FOREST TREE SPECIES. Jour. Forestry 56: 809-815, illus.
Reviews American work in hybridization and concludes that, while successes have not yet been remarkable, hybridization has an important place among methods of improving the adaptability and the pest-resistance of forest trees.

* ECHOLS, R. M.
1959. EVALUATING TREES AND STANDS FROM LARGE INCREMENT CORES. Soc. Amer. Foresters Proc. 1958: 145-147, illus.
The Southern Institute of Forest Genetics is using 10-millimeter increment cores to study specific gravity, proportion of summerwood, fiber length, fibril angle, and other factors that influence wood quality.

* ————
1959. THE AMPLISCOPE—AN INSTRUMENT FOR WOOD-FIBER MEASUREMENTS. Jour. Forestry 57: 43-44, illus.
Construction details of a device for throwing a magnified image of small objects on a glass screen.

————
1960. EFFECTS OF GROWING SPACE ON WOOD SPECIFIC GRAVITY IN LOBLOLLY PINE. Soc. Amer. Foresters Proc. 1959: 140-143, illus.
Trees were planted in central Louisiana at square spacings of 4, 6, 8, and 10 feet, thinned to 4 densities at age 20 years and remeasured 10 years later. For all degrees of thinning, 6-foot spacings made the greatest gain in specific gravity between age 20 and age 30. The 8-foot spacing produced the most volume.

* ————
1961. LIQUID DISPERSION METHOD FOR MOUNTING WOOD FIBERS ON SLIDES. Forest Sci. 7: 369-370, illus.
Microscope slides are placed in a container filled with water (or xylene for dehydrated material). Macerated and stained fibers are stirred into the liquid and allowed to settle in an even layer. The liquid is drained off very slowly, the slides lifted out, and cover slips mounted.

GODDARD, R. E., and ALLEN, R. M.
1955. CONTROLLED POLLINATION TECHNIQUES. Third South. Forest Tree Impr. Conf. Proc. 1955: 67-70.
Current techniques with southern pines.

GRANO, C. X.
1958. A TIMESAVING SLIDE FOR TRAPPING ATMOSPHERIC POLLEN. Forest Sci. 4: 94-95, illus.
A pressure-sentitive polyester tape was mounted on a microscope slide made of aluminum.

* GRIGSBY, H. C.
1959. TWO PROMISING PINE HYBRIDS FOR THE MID-SOUTH. South. Lumberman 198(2466): 32-33, illus.
In southern Arkansas, the cross of slash and shortleaf pine is showing resistance to tipmoth and is growing faster than shortleaf pine. The hybrid of loblolly and south Florida slash pine is also doing well.

HENRY, B. W.
1955. SOUTHERN INSTITUTE OF FOREST GENETICS. Third South. Forest Tree Impr. Conf. Proc. 1955: 99-101.
Objectives and plans of the newly established Institute.

————
1956. PROGRESS AT INSTITUTE OF FOREST GENETICS. Forest Farmer 16(3): 4-5, 18, illus.
In 2 years, the Southern Institute of Forest Genetics has initiated or intensified more than 50 studies.

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1957. BETTERING NATURE'S BEST. Forest Farmer 17(2): 10-11, illus.
"Blessed with four native pine species that rank with the best in the world, are we a bit presumptuous to think that we can make them still better? Not at all. On the contrary, it is practically a sure bet . . . . Through selection and hybridization, differentiating genetic from environmental effects, and studying the physiology of the resultant tree, the Southern Institute of Forest Genetics, along with other research organizations, is embarked on a program to 'better the best'."

+ ————
1959. DISEASES AND INSECTS IN THE SOUTHWIDE PINE SEED SOURCE STUDY PLANTATIONS DURING THE FIRST FIVE YEARS. Fifth South. Forest Tree Impr. Conf. Proc. 1959: 12-17.
Two pests have been of major importance. Tipmoth injury is severe in most shortleaf and loblolly plantations, irrespective of seed source, and is impeding height growth. Intensity of fusiform rust is variable among the slash and loblolly plantations. Its incidence consistently differs between seed sources in loblolly plantings, but in only one case with slash pine.

* ———— and BERCAW, T. E.
1956. SHORTLEAF-LOBLOLLY HYBRID PINES FREE OF FUSIFORM RUST AFTER 5 YEARS' EXPOSURE. Jour. Forestry 54: 779.
Five years after planting, none of the 31 surviving hybrid seedlings had rust symptoms, while 67 percent of some adjacent slash pine seedlings had typical cankers.

———— and COYNE, J. F.
1955. OCCURRENCE OF PESTS IN SOUTHWIDE PINE SEED SOURCE STUDY. Third South. Forest Tree Impr. Conf. Proc. 1955: 49-54.
Occurrence of fusiform rust, tip moth, and webworm by geographic sources of loblolly and slash pine in two-year-old plantations.

* ———— DORMAN, K. W., and WAKELEY, P. C.
1961. FOREST GENETICS PUBLICATIONS BY THE SOUTHEASTERN AND SOUTHERN FOREST EXPERIMENT STATIONS THROUGH 1961. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 192, 27 pp.
Annotated bibliography.

* ———— and HEPTING, G. H.
1957. PEST OCCURRENCES IN 35 OF THE SOUTHWIDE PINE SEED SOURCE STUDY PLANTATIONS DURING THE FIRST THREE YEARS. U. S. Forest Serv. South. Forest Expt. Sta., 7 pp., illus.
Drouth has caused most of the mortality so far. Fusiform rust is building up rapidly. The Nantucket tip moth is widespread in loblolly and shortleaf plantings, and may be retarding height growth appreciably. Brown-spot needle disease is being controlled in longleaf plantations with fungicides, but it and Hypoderma needle blight may be causing growth loss on loblolly. No other pests yet appear serious.

* HESSELTINE, C. W., and SNYDER, E. B.
1958. ATTEMPTS TO FREEZE-DRY PINE POLLEN FOR PROLONGED STORAGE. Torrey Bot. Club Bul. 85(2): 134-135.
Lyophilization techniques by which fungus spores have been stored successfully for 15 years failed with pine pollen.

JEWELL, F. F.
1957. INOCULATION TECHNIQUES IN STUDIES OF RUST RESISTANCE. Fourth South. Forest Tree Impr. Conf. Proc. 1957: 67-69.
Exploratory studies at the Southern Institute of Forest Genetics give promise that a technique can be developed for testing for rust resistance in the southern pines.

* ———
1957. PREVENTING CONE RUST ON SLASH PINE BY POLLINATION TECHNIQUES USED IN BREEDING PROGRAMS. Phytopath. 47: 241-242, illus.
Rust infection of first-year cones of slash pine was prevented by routine bagging of the conelets for controlled pollination; 27 percent of the nonbagged cones became infected. Infection of slash pine cones seems to coincide with the period of pollination.

* ———
1958. SOFTENING SLASH PINE TISSUES FOR SERIAL SECTIONING. Stain Technol. 33(4): 191-192.
A 10-percent aqueous solution of glycerol was found best for softening serial paraffin sections for anatomical studies of slash pine infected with fusiform rust.

* ———
1958. STAIN TECHNIQUE FOR RAPID DIAGNOSIS OF RUST IN SOUTHERN PINES. Forest Sci. 4: 42-44, illus.
Two techniques, involving orseillin-BB and aniline blue, and safranin-O and aniline blue, have been used successfully for distinguishing the mycelium of Cronartium fusiforme *in hand sections of slash and loblolly pines and of* C. cerebrum *in shortleaf pine.*

———
1959. DISEASE RESISTANCE STUDIES IN TREE IMPROVEMENT RESEARCH. Fifth South. Forest Tree Impr. Conf. Proc. 1959: 18-20.
"The ultimate aim of disease resistance research is to be able to incorporate the factors for resistance . . . into trees possessing other superior traits as well."

* ———
1961. ARTIFICIAL TESTING OF INTRA- AND INTERSPECIES SOUTHERN PINE HYBRIDS FOR RUST RESISTANCE. South. Forest Tree Impr. Conf. Proc. 6: 105-109.
Crossing slash or loblolly with shortleaf will not consistently yield resistant progenies. Resistance in shortleaf hybrids appears more complicated than inheritance of a simple dominant factor.

* ———
1961. INFECTION OF ARTIFICIALLY INOCULATED SHORTLEAF PINE HYBRIDS WITH FUSIFORM RUST. U. S. Dept. Agr. Plant Dis. Rptr. 45: 639-640, illus.
Characteristic rust galls developed on at least a few progenies from each of five crosses of shortleaf × slash pine and one cross of shortleaf × loblolly pine. Differences in the number of galled individuals from the various crosses appeared traceable to particular shortleaf parents.

——— and HENRY, B. W.
1959. BREEDING FOR RESISTANCE TO SOUTHERN FUSIFORM RUST. (Abstract.) IX Internatl. Bot. Cong. Proc., pp. 181-182.
See next entry.

* ——— and HENRY, B. W.
1961. BREEDING FOR RESISTANCE TO SOUTHERN FUSIFORM RUST. *In* Recent Advances in Botany, pp. 1694-1695. Toronto, Ontario.
Text of a paper read at International Botanical Congress in 1959. Data supported the initial hypotheses on possible sources of resistance, i. e., natural resistance in susceptible pine species and inherited resistance in hybrid progenies having shortleaf as a parent. At that time resistance of shortleaf appeared to be transmitted as a dominant factor to the F_1 hybrids from crosses of shortleaf × slash and shortleaf × loblolly.

MCGREGOR, W.H.D., ALLEN, R. M., and KRAMER, P. J.
1961. THE EFFECT OF PHOTOPERIOD ON GROWTH, PHOTOSYNTHESIS, AND RESPIRATION OF LOBLOLLY PINE SEEDLINGS FROM TWO GEOGRAPHIC SOURCES. Forest Sci. 7: 342-348, illus.
Florida seedlings grew taller than Georgia seedlings under long days (15 hours). Georgia seedlings photosynthesized faster than Florida seedlings because of a greater amount of foliage rather than a faster rate per unit of fascicle length.

* MCKNIGHT, J. S., and BONNER, F. T.
1961. POTENTIALS AND PROBLEMS OF HARDWOOD TREE IMPROVEMENT. South. Forest Tree Impr. Conf. Proc. 6: 164-178.
Literature references and tables of information useful in tree-improvement programs for southern hardwoods.

* MCLEMORE, B. F., CROW, A. B., and WAKELEY, P. C.
1961. DRY-MATTER CONTENT OF LOBLOLLY PINE NEEDLES APPEARS UNRELATED TO GEOGRAPHIC SEED SOURCE. Forest Sci. 7: 373-375.
Samples from 25 sources representing extremes in the species' range showed no relation between dry-matter content and latitude, longitude, or climate.

* MAISENHELDER, L. C.
1961. SELECTION OF POPULUS CLONES FOR SOUTHERN BOTTOM LANDS. South. Forest Tree Impr. Conf. Proc. 6: 110-115.
Five clones of native cottonwood and one Euramerican hybrid have thus far emerged as the best Populus planting stock. Some other hybrids grow more slowly than cottonwood but have attributes worth perpetuating.

* MITCHELL, H. L., and WHEELER, P. R.
1959. THE SEARCH FOR WOOD QUALITY. Two parts. Forest Farmer 18(4): 4-6, illus.; 18(5): 10-12, illus. *Also as* WOOD QUALITY OF MISSISSIPPI'S PINE RESOURCES. U. S. Forest Serv. Forest Prod. Lab. Rpt. 2143, 20 pp., illus.
Highlights of wood-density research in southern pines, carried on in connection with the third Forest Survey of Mississippi.

——— and WHEELER, P. R.
1960. SPECIFIC GRAVITY—A MEASURE OF INTRINSIC WOOD QUALITY. Soc. Amer. Foresters Proc. 1959: 53-57, illus.
Relationships of specific gravity to age of wood, species, and latitude and longitude of the growing site were investigated by extensive sampling of the major southern pine species in Mississippi.

* NAMKOONG, GENE.
1960. FEMALE FLOWERS ON ONE-YEAR-OLD PITCH PINE. Forest Sci. 6: 163, illus
New degree of flowering precocity for pines.

* NEELANDS, R. W., and JEWELL, F. F.
1961. THE SEARCH FOR PEST-RESISTANT TREES. Forest Farmer 21(1): 15, 26, 28, illus.
Work on fusiform-rust resistance at the Southern Institute of forest Genetics exemplifies the possibilities of breeding for pest resistance.

PUTNAM, J. A.
1955. POSSIBILITIES OF GENETICS RESEARCH IN SOUTHERN HARDWOODS. Third South. Forest Tree Impr. Conf. Proc. 1955: 44-47.
A little work has been done on artificial regeneration and on genetic selection of cottonwood, but virtually none on other valuable hardwood species.

* RUSSELL, T. E.
1960. WHY GAMBLE ON PINE SEED? Forests and People 10(3): 35, 42, 46-47, illus.

" . . . Steps must be taken to improve the quality of Louisiana's pine seed, and to put seed procurement on the same high level as other forest practices."

SCHOENIKE, R. E.
1956. PLASTIC TUBES FOR CONTROLLED POLLINATION OF PINE. Jour. Forestry 54: 135, illus.
Small plastic tubes can be used in pine tree breeding.

SNYDER, E. B.
1957. POLLEN HANDLING. Fourth South. Forest Tree Impr. Conf. Proc. 1957: 111-115.
Means of hastening the shedding of pollen, and of extracting and storing pollen.

* ———— (Editor)
1959. GLOSSARY FOR FOREST TREE IMPROVEMENT WORKERS. U. S. Forest Serv. South. Forest Expt. Sta. for Soc. Amer. Foresters, 22 pp
Simplified definitions of about 160 terms.

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1960. A FOREST-GENETICS LITERATURE CLASSIFICATION BASED ON THE OXFORD DECIMAL CLASSIFICATION (ODC). Silvae Genetica 9: 167-168.
Authorized expansion of pertinent headings of the ODC. Harmonizes with the classification used in Forestry Abstracts.

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1961. EXTRACTING, PROCESSING, AND STORING SOUTHERN PINE POLLEN. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 191, 14 pp., illus.
Recommends extracting pollen from ripe strobili in dry, warm, moving air and storing it at 22 percent relative humidity and 32° F.

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1961. MEASURING BRANCH CHARACTERS OF LONGLEAF PINES. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 184, 4 pp., illus.
From measurements of all mature branches on 48 longleaf trees it was deduced that the best place to determine inherent branch angles and diameters was a "zone of equilibrium" in the middle crown where diameters of successive branches down the bole increased in proportion to bole diameter.

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1961. RACIAL VARIATION IN ROOT FORM OF LONGLEAF PINE SEEDLINGS. Sixth South. Forest Tree Impr. Conf. Proc. 1961: 53-59, 64a.
Roots of 1-year-old longleaf pines from seed sources in southeastern Georgia are more fibrous than those of seedlings representing sources in Alabama, Mississippi, and Louisiana.

* ———— GRIGSBY, H. C., and HIDALGO, J. U.
1961. X-RADIATION OF SOUTHERN PINE SEED AT VARIOUS MOISTURE CONTENTS. Silvae Genetica 10: 125-131, illus.
Zero to 1,800 r were applied to determine mortality and growth depression at dosages strong enough to yield mutations. Stratification prior to irradiation produced more severe damage than other methods of moistening the seed. Filtering the rays intensified effects noted for unfiltered rays. One-year-old shortleaf seedlings from seed receiving 300 to 400 r were heavier than controls but cone production at 7 years was not stimulated.

* ———— and ROSSOLL, HARRY.
1958. CLIMBING SOUTHERN PINES SAFELY. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 159, 17 pp., illus.
Illustrated guide to safe climbing with sectional ladders.

———— and ROSSOLL, HARRY.
1959. CLIMBING TREES IS DANGEROUS! Forests and People 9(1): 13-14, illus. *Also in* Forest World, pp. 13-15. June 1962.
See preceding entry.

THIRD SOUTHERN CONFERENCE ON FOREST TREE IMPROVEMENT.
1955. PROCEEDINGS. Compiled and processed by the South. Forest Expt. Sta., 132 pp., illus.
Texts of papers read at the Conference, which was held in New Orleans, Louisiana, on January 5 and 6, 1955.

WAHLGREN, H. E., and FASSNACHT, D. L.
1959. ESTIMATING TREE SPECIFIC GRAVITY FROM A SINGLE INCREMENT CORE. U. S. Dept. Agr. Forest Prod. Lab. Rpt. 2146, 24 pp., illus.
Describes method of estimating average specific gravity of the merchantable volume in a southern yellow pine tree from a single increment core.

WAKELEY, P. C.
1955. SET-BACKS AND ADVANCES IN THE SOUTHWIDE PINE SEED SOURCE STUDY. Third South. Forest Tree Impr. Conf. Proc. 1955: 10-13.
Notes on racial variations in the nursery and early plantation phases. Losses to drought in western part of study territory necessitate additional longleaf and shortleaf pine plantations.

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1957. FOREST TREE-IMPROVEMENT WORK IN THE SOUTH. South. Lumberman 195(2441): 126-129, illus.
Summary of work being done by educational institutions, Federal agencies, State departments of forestry, industrial organizations, and the Committee on Southern Forest Tree Improvement.

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1958. SUMMARY OF FOREST TREE IMPROVEMENT WORK IN THE SOUTH. *In* Lake States Forest Tree Impr. Conf. Proc. 3: 65-71. U. S. Forest Serv. Lake States Forest Expt. Sta. Sta. Paper 58.
See preceding entry.

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1959. FIVE-YEAR RESULTS OF THE SOUTHWIDE PINE SEED SOURCE STUDY. Fifth South. Forest Tree Impr. Conf. Proc. 1959: 5-11.
Preliminary analyses have shown statistically significant variations, attributable to seed source, in the survival and average height of all four major southern pines, and in the rust-susceptibility of loblolly pine.

* ————
1961. RESULTS OF THE SOUTHWIDE PINE SEED SOURCE STUDY THROUGH 1960-61. Sixth South. Forest Tree Impr. Conf. Proc. 1961: 10-24, illus.
Significant variations in survival and height appear among different geographic sources of both loblolly and shortleaf pine, especially from north to south. In longleaf they appear almost as much from east to west as from north to south. Loblolly varies significantly in fusiform rust infection, especially from east to west. Compared to these species, slash pine north and west of mid-Florida exhibits little racial variation.

* ———— ZOBEL, B. J., GODDARD, R. E., ROBINSON, H. F., SNYDER, E. B., EVANS, T. C., and FREESE, FRANK.
1960. MINIMUM STANDARDS FOR PROGENY-TESTING SOUTHERN FOREST TREES FOR SEED-CERTIFICATION PURPOSES. U. S. Forest Serv. South. Forest Expt. Sta. for the Com. on South. Forest Tree Impr., 19 pp.
Twenty-one standards with explanatory text, specifying the plant material, experimental design, field techniques, records, statistical analyses, and reporting proposed by a special Subcommittee of the Committee on Southern Forest Tree Improvement as the minimum basis for certifying genetic improvement of forest tree seed.

WHEELER, P. R., and MITCHELL, H. L.
1959. SPECIFIC GRAVITY VARIATION IN MISSISSIPPI PINES. Fifth South. Forest Tree Impr. Conf. Proc. 1959: 87-96, illus. *Also as* U. S. Forest Serv. Forest Prod. Lab. Rpt. 2250, 10 pp., illus. 1962.
Of the single variables tested to predict core specific gravity, the most important was the reciprocal of age. The four southern pines showed true variation in core specific gravity according to geographic location.

ZAHNER, ROBERT.
1956. GENETICALLY SIMILAR SEEDLINGS FOR PHYSIOLOGY EXPERIMENTS. Jour. Forestry 54: 190.
Seedlings of different ancestry may respond differently to treatment.

ECONOMICS

FOREST SURVEY

Alabama

JUDSON, G. M.
1956. ALABAMA'S FORESTS. Ala. Forest Prod. Dir., 1956 ed., pp. 21, 24.
Findings of second Forest Survey, in brief.

MUNTZ, H. H.
1955. BIRMINGHAM AREA FORESTS SURVEYED. Ala. Lumberman 7(4): 10, 23-25, illus.
Summary of Forest Survey findings in Birmingham area, and recommendations for improving the forest.

* STERNITZKE, H. S.
1961. ALABAMA HAS MILLIONS OF TONS OF RESINOUS STUMPWOOD AVAILABLE. Naval Stores Rev. 71(8): 10-11, illus. *Also in* Ala. Forest Prod. Dir. 5(10): 107. 1962.
At the current rate of removal there is at least 10 years' supply in the five main producing counties.

Arkansas

* REYNOLDS, R. R., and STERNITZKE, H. S.
1961. TIMBER STAND IMPROVEMENT OPPORTUNITIES IN SOUTHWEST ARKANSAS. South. Lumberman 203 (2530): 28, 30-31, illus.
Of the pine acreage, 23 percent is inadequately stocked but has an adequate seed source; 27 percent has neither adequate stocking nor adequate seed source.

* STERNITZKE, H. S.
1956. TIMBER SUPPLIES FOR INDUSTRY IN ARKANSAS. U. S. Dept. Agr. Forest Resource Rpt. 11, 32 pp., illus.
Analysis of Arkansas' present forest resource, and of changes since the survey of 1934-36.

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1959. FOREST RESOURCES IN SOUTHWEST ARKANSAS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 121.
Forest acreage in southwest Arkansas has increased 10 percent since 1949, and pine growing stock is up 30 percent. Hardwood growing stock has declined 10 percent.

* ———
1959. FOREST RESOURCES IN THE OUACHITAS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 124.
Softwood sawtimber volume in the Ouachita Mountain region of Arkansas has increased 44 percent since 1951, hardwood sawtimber volume has declined 37 percent. Total softwood growing stock has risen 39 percent.

* ———
1960. ARKANSAS FORESTS. U. S. Forest Serv. South. Forest Expt. Sta. Forest Survey Release 84, 58 pp., illus.
Softwood growing stock in the State has increased 31 percent since 1951. Hardwood has declined 9 percent. Forest acreage totals 20.8 million: up 7 percent.

* ———
1960. ARKANSAS FORESTS REVISITED. South. Lumberman 201 (2513): 131-133, illus.
See preceding entry.

* ———
1960. ARKANSAS FOREST SURVEY COMPLETED. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 130.
See second entry above.

Louisiana

* CASSADY, J. T., and WHEELER, P. R.
1956. LOUISIANA NEEDS MORE PLANTED FORESTS. Forests and People 6(1): 18-21, illus.
The Forest Survey found that 2.8 million acres of potential pine land in Louisiana must be planted if they are to be restored to early productivity. Another 3 million acres lack adequate stocking, but have enough residual pines to regenerate. The remaining 3.2 million acres of pine land are adequately stocked and highly productive.

* SIEGEL, W. C.
1960. FOREST LANDOWNERSHIP IN LOUISIANA. Ed. 4, La. Forestry Comn. Bul. 5, 116 pp.
Forest landownerships of 500 acres or more are listed by parish, with the owner's name and address. Tracts of less than 500 acres are counted but not listed.

SOUTHERN FOREST EXPERIMENT STATION.
1955. FORESTS OF LOUISIANA, 1953-54. U. S. Forest Serv. South. Forest Expt. Sta. Forest Survey Release 75, 64 pp., illus.
Complete, final statistics from the Forest Survey.

STERNITZKE, H. S.
1955. CYPRESS IS COMING BACK. Forests and People 5(4): 40-41, illus. *Also in* South. Lumberman 191(2393): 113.
Louisiana has more cypress than it did 20 years ago. The volume in large trees has decreased, but that in small trees has risen.

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1955. LOUISIANA'S STUMPWOOD SUPPLY. Naval Stores Rev. 65(3): 11, 20, illus.
Louisiana has about 5.1 million tons of longleaf pine stumpwood, enough to last 10 or 15 years at the present rate of removal.

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1955. LOUISIANA'S TIMBER SUPPLY, 1953-54. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 96.
See third entry above.

——— and WHEELER, P. R.
1955. LOUISIANA FORESTS TURN THE CORNER. Forests and People 5(2): 8-19, illus.
Popular account of the information in Forest Survey Release 75. See fourth entry above.

WHEELER, P. R., and CASSADY, J. T.
1956. THE HARDWOOD CONTROL JOB ON LOUISIANA'S PINELANDS. Forests and People 6(2): 22-23, 45, illus.
Two out of every 3 acres of Louisiana's uplands are encumbered with low-value hardwoods.

Mississippi

* SOUTHERN FOREST EXPERIMENT STATION.
1958. KEMPER COUNTY CAN GROW TIMBER. 4 pp., illus.
NESHOBA COUNTY CAN GROW TIMBER. 4 pp., illus.
NOXUBEE COUNTY CAN GROW TIMBER. 4 pp., illus.
WINSTON COUNTY CAN GROW TIMBER. 4 pp., illus.
Popular booklets summarizing basic measures to realize full potential of the forests in four counties of east-central Mississippi. See third entry below.

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1958. MISSISSIPPI FORESTS. U. S. Forest Serv. South. Forest Expt. Sta. Forest Survey Release 81, 52 pp., illus.
Complete report on new Forest Survey of Mississippi.

* STERNITZKE, H. S.
1958. MISSISSIPPI SURVEY COMPLETED. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 116.
See entry above.

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1959. FOREST DEVELOPMENT OPPORTUNITIES IN NORTH CENTRAL MISSISSIPPI. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 173, 40 pp., illus.
How development of the forests could strengthen the economy of Kemper, Neshoba, Noxubee, and Winston Counties. The conclusions and recommendations may also be applicable in neighboring counties that share similar timberland problems and opportunities.

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1959. MISSISSIPPI'S STUMPWOOD SUPPLY. Naval Stores Rev. 68(12): 12-13, illus.
The total supply is 4,500,000 tons. Average rate of removal is 300,000 tons annually. Four wood naval stores plants are still active in the State.

Oklahoma

* SOUTHERN FOREST EXPERIMENT STATION.
1957. FORESTS OF EAST OKLAHOMA, 1955-56. U. S. Forest Serv. South. Forest Expt. Sta. Forest Survey Release 79, 34 pp., illus.
Forest Survey statistics for the main belt of commercial timber in the State.

* STERNITZKE, H. S.
1957. EAST OKLAHOMA SURVEY COMPLETED. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 109.
See entry above.

Tennessee

* STERNITZKE, H. S.
1955. TENNESSEE'S TIMBER ECONOMY. U. S. Dept. Agr. Forest Resource Rpt. 9, 56 pp., illus.
Analysis and statistics.

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1961. TENNESSEE FOREST ACREAGE INCREASING. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 136. *Also as* MORE TIMBER IN TENNESSEE. South. Lumberman 204 (2539): 51. 1962.
In the past decade, Tennessee's commercial forest acreage has increased 9 percent, largely by reversion of former agricultural land. It now stands at 13,432,400.

Texas

* SOUTHERN FOREST EXPERIMENT STATION.
1956. FORESTS OF EAST TEXAS, 1953-55. U. S. Forest Serv. South. Forest Expt. Sta. Forest Survey Release 77, 51 pp., illus.
Complete statistics.

* STERNITZKE, H. S.
1956. FOREST RESOURCES OF EAST TEXAS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 104.
See preceding entry.

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1956. STUMPWOOD SUPPLIES IN SOUTHEAST TEXAS. Naval Stores Rev. 66(6): 8, illus.
Of the total supply of 2.5 million tons about 1 million tons is presently available by push-dozer operation. Around a quarter of a million tons is being removed annually.

WHEELER, P. R.
1956. PRELIMINARY RESULTS OF THE FOREST SURVEY OF EAST TEXAS 1953-1955. Tex. Forest News 35(2): 4-5, illus.
"Southeast Texas is still growing trees and producing wood products at a good rate, and is in a fair position to continue . . . . In northeast Texas the best thought and effort of both public and private agencies will be required to assure the continued productivity of the forests."

Regional

* CHRISTOPHER, J. F.
1955. RISE IN PULPWOOD CUT CONTINUES. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 97.
See Stover and Christopher, 1955.

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1956. PULPWOOD UPSURGE CONTINUES. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 104.
See Cruikshank and McCormack, 1956.

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1957. MIDSOUTH CHARCOAL PRODUCTION. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 108.
By the end of 1956, 29 charcoal plants were operating.

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1957. SOUTHERN PULPWOOD HARVEST SOARS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 110.
See Christopher and Nelson, 1957.

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1958. SOUTHERN PULPING CAPACITY EXPANDS DESPITE PRODUCTION DROP. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 117.
See McCormack, 1958.

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1959. SOUTH'S PULP INDUSTRY STILL GROWING. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 122.
See Christopher and Nelson, 1959.

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1960. 1959 SETS RECORD FOR SOUTHERN PULPWOOD. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 129.
See Todd and Nichols, 1960.

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1961. BIGGEST SOUTHERN PULPWOOD HARVEST. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 133.
See Christopher and Nelson, 1961.

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1961. SOUTHERN WOOD INDUSTRIES ARE IN THE CHIPS. South. Lumberman 203(2527): 25, illus.
About 900 southern wood-using plants are currently making pulp chips from plant residues. The volume in 1960 was 2.9 million cords, worth $40 million.

* CHRISTOPHER, J. F., and NELSON, MARTHA E.
1957. 1956 PULPWOOD PRODUCTION IN THE SOUTH. U. S. Forest Serv. South. Forest Expt. Sta. Forest Survey Release 80, 17 pp., illus.
Total cut of roundwood was 19,685,800 cords, of which 14 percent was hardwood. Residues from wood-using industries added another 659,100 cords.

* ———— and NELSON, MARTHA E.
1959. SOUTHERN PULPWOOD PRODUCTION, 1958. U. S. Forest Serv. South. Forest Expt. Sta. Forest Survey Release 82, 24 pp., illus.
Reports total 1958 pulpwood harvest of 20,232,800 cords, of which 2,944,600 cords was hardwood and 1,785,400 was chipped residues. Reviews developments in southern pulpwood production and mill capacity since 1946.

* ———— and NELSON, MARTHA E.
1961. SOUTHERN PULPWOOD PRODUCTION, 1960. U. S. Forest Serv. South. Forest Expt. Sta. Forest Survey Release 85, 29 pp., illus.
Volume of bolts was 20,595,500 cords, of which 80 percent was pine. Another 2,877,300 cords was in the form of chipped residues.

* CRUIKSHANK, J. W., and MCCORMACK, J. F.
1956. 1955 PULPWOOD PRODUCTION IN THE SOUTH. U. S. Forest Serv. Southeast. Forest Expt. Sta. Forest Survey Release 47, 32 pp., illus.
The total was 18,014,600 cords, an increase of 10.7 percent over 1954. Pine production was up 9.8 percent, hardwood up 17.5 percent.

* JANSSEN, P. L., and WEILAND, M. R.
1960. SOFTWOOD DISTRIBUTION MAPS FOR THE SOUTH. U. S. Forest Serv. South. Forest Expt. Sta. Forest Survey Release 83, 12 pp., illus.
Relative concentration and approximate range of 11 softwood species.

* MCCORMACK, J. F.
1958. 1957 PULPWOOD PRODUCTION IN THE SOUTH. U. S. Forest Serv. Southeast. Forest Expt. Sta. Forest Survey Release 53, 17 pp., illus.
The total was 19,783,000 cords. Of this, hardwood comprised 2,866,000 cords and chipped mill residues 1,200,000 cords.

* NEELANDS, R. W., and JUDSON, G. M.
1958. ARKANSAS AIRLIFT. Forests and People 8(4): 30-31, 38-39, illus.
A Bell 47G helicopter was used to transport Forest Survey cruising teams to difficult plots in the Delta region of Arkansas. At present costs, the helicopter appears economical only in large forested areas that have natural openings for landing points, but are otherwise extremely difficult of access.

* STERNITZKE, H. S., and CHRISTOPHER, J. F.
1961. RECENT TRENDS IN SOUTHERN PINE PRODUCTION. Pulpwood Prod. 9(11): 1, 4, illus.
Total output has been relatively stable since 1950 because a rise in production of pulpwood offset a decline in sawlogs. In terms of annual output, pulpwood has been dominating the South's pine timber economy since 1957.

* ———— and PUTNAM, J. A.
1956. FORESTS OF THE MISSISSIPPI DELTA. U. S. Forest Serv. South. Forest Expt. Sta. Forest Survey Release 78, 42 pp., illus.
Forest land and timber volume, cut, and growth in the Delta portion of Arkansas, Louisiana, and Mississippi.

STOVER, W. S., and CHRISTOPHER, J. F.
1955. 1954 PULPWOOD PRODUCTION IN THE SOUTH. U. S. Forest Serv. South. Forest Expt. Sta. Forest Survey Release 76, 15 pp., illus.
In 1954, pulpwood production in the South was 16,269,600 cords, the largest harvest on record. The volume of hardwood pulpwood, 2,128,800 cords was 11 percent more than in 1953; pine production was very slightly less than in 1953.

* TODD, A. S., JR., and NICHOLS, AGNES C.
1960. 1959 PULPWOOD PRODUCTION IN THE SOUTH. U. S. Forest Serv. Southeast. Forest Expt. Sta. Forest Survey Release 56, 23 pp., illus.
Southern pulpwood harvest by State and county, size and location of mills, number of companies drawing wood from individual counties.

WHEELER, P. R.
1955. FOREST RESOURCE CHANGES FOUND IN ALABAMA, ARKANSAS, LOUISIANA, AND MISSISSIPPI. The Unit, News Letter 56, pp. 44-52, illus. *Also in* South. Pulp and Paper Mfr. 18(3): 86, 88, 90.
Trends in timber inventory.

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1958. THE BOTTOMLAND HARDWOOD FOREST RESOURCE. La. State Univ. Seventh Ann. Forestry Symposium Proc. 1958: 1-4.
Southern bottom-land hardwood types cover almost 37 million acres. This area supports 94 billion board feet, of which a little less than half is in trees 18 inches in d.b.h. and larger. The total acreage remains fairly stable, but the acreage in the bottoms of the Mississippi is shrinking. The average stand contains 2,500 board feet per acre and grows at the rate of 5 or 6 percent.

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1960. SOUTHERN FOREST REGIONS. Forest Farmer (Eighth Manual ed.) 19(7): 28-31, illus. *Also in* (Ninth Manual ed.) 20(7): 24-27, illus. 1961. *Also in* (Tenth Manual ed.) 21(7): 22-24, illus. 1962.
Acreages and characteristics of major types.

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1961. DATA AND SERVICES AVAILABLE FROM THE FOREST SURVEY AND PLANS FOR THE FUTURE. Amer. Pulpwood Assoc. Tech. Paper 61-P-4, 9 pp., illus.
Current procedures of the Forest Survey, as conducted by the Southern Forest Experiment Station.

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1961. SOUTH DESTINED TO BECOME NATION'S WOOD BASKET. Forest Farmer 20(13): 6-7, 18, illus.
The South may soon have to furnish more than half the wood needed by a vastly increased U. S. population. She has the forest soils, acreage, and species, but land managers will have to redouble their efforts and processors improve utilization techniques.

* ————
1961. SOUTHERN WOOD SUPPLIES—TODAY AND TOMORROW. The Unit, News Letter 90, pp. 9-11, illus.
The gradual disappearance of the West's old-growth timber will increase the demand on the second-growth southern pine forests.

———— and CRUIKSHANK, J. W.
1956. THE SOUTH'S FOREST RESOURCE. Jour. Forestry 54: 629-632, illus.
Area and ownership, major forest types, condition of the forest, sawtimber and cordwood volumes, growth versus cut.

* ———— and STERNITZKE, H. S.
1956. TIMBER TRENDS IN THE MID-SOUTH. South. Lumberman 193(2417): 179-181, illus.
Changes in the forest resource, as revealed by comparing findings of the recently completed Second Forest Survey with those of the First Survey of the 1930's.

* WILSON, R. C., and CHRISTOPHER, J. F.
1958. THERE'S AN ADEQUATE SUPPLY OF WOOD UTILITY POLES. Telephony 155(4): 28-30, 56-57, illus. *Also in* Wood Preserv. News 36(11): 10-12, illus.
There are at least 1.12 billion softwood trees clearly suitable for poles growing on commercial forest lands in the continental United States. Southern pines have dominated the pole market for many years and furnish about 75 percent of the total national production.

TAXATION

* SIEGEL, W. C., and PERRY, J. D.
1961. FOREST TAXATION IN LOUISIANA. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 187, 14 pp., illus.
Statistical summary of a study to determine trends during the past two decades and trace preliminary effects of a yield-tax law enacted in 1954.

PRODUCTION AND MARKETING

* BARRACLOUGH, S. L., and PLEASONTON, ALFRED.
1957. DATA FOR PLANNING WOODLAND OPPORTUNITIES ON WEST TENNESSEE FARMS. Tenn. Agr. Expt. Sta. Bul. 276, 64 pp., illus.
Labor requirements, timber yields expected under two levels of management, and procedures for fitting forestry into improved farming systems.

* CHRISTOPHER, J. F.
1960. PULPWOOD PRICE TRENDS IN THE MID-SOUTH. Pulpwood Prod. 8(8): 28, illus.
Though production increased in 1959 prices remained the same as in 1958. Open-market prices for chipped mill residues averaged $6.21 per ton for pine and $4.97 for hardwood.

* ———
1961. 1960 PULPWOOD PRICES IN THE MID-SOUTH. South. Pulp and Paper Mfr. 24(7): 46, illus.
Prices for pine bolts increased from $15.28 per cord in 1957 to $16.07 in 1960. Hardwood prices have been relatively stable. Open-market prices of chipped mill residues have been fairly constant during the past 4 years, averaging $6.22 per ton for pine and $4.48 for hardwood. Contractors continue to truck increasing proportions of their roundwood to mechanized woodyards and to millyards.

* DUERR, W. A., FEDKIW, JOHN, and GUTTENBERG, SAM.
1956. FINANCIAL MATURITY: A GUIDE TO PROFITABLE TIMBER GROWING. U. S. Dept. Agr. Tech. Bul. 1146, 74 pp., illus.
A tree is financially mature when its expected value increase no longer equals or exceeds the net return possible—the so-called alternative rate of return—from liquidating the tree, using its cash value elsewhere, and turning the growing space over to other trees. Mathematical appendix compares the concept of financial maturity with that of soil rent.

* GIBBS, C. B., and STEPHENSON, G. K.
1958. PROFITS AND PROBLEMS IN EAST TEXAS WOODLAND CONSERVATION. Tex. Jour. Sci. 10: 302-307.
Few small forest owners in east Texas as yet manage their timber well. "We feel that the classic excuses, ignorance of basic principles of forestry or lack of market information, are no longer of primary importance . . . . Much more important, apparently, is the poor competitive position of the seller of a small amount of stumpage, and the fact that most small owners have urgent and recurring needs for cash." Restoration of the most depleted small forests is unlikely without public financial assistance.

* GUTTENBERG, SAM.
1956. INFLUENCE OF TIMBER CHARACTERISTICS UPON STUMPAGE PRICES. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 146, 14 pp., illus.
A study of pine sawtimber sales from National Forests in Mississippi, Louisiana, and Texas showed that stumpage prices tend to increase with total volume offered, cut per acre, and grade of the trees; prices decrease in proportion to the low-grade hardwood tied into the sales. The study suggests the possibility of a price-reporting service that would permit appraisal of specific parcels of timber by comparison, in terms of the main value determinants, with the going market.

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1956. PINE PRICES MIRROR TIMBER DIFFERENCES. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 102.
See preceding entry.

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1957. REDUCING MANPOWER FOR PULPWOODING. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 111.
See Guttenberg and Perry, 1957.

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1957. STUMPAGE PRICE REPORTS AS A STIMULUS TO TIMBER GROWING. Soc. Amer. Foresters Proc. 1956: 132-133.
The uses to which stumpage price reports lend themselves, and the need for responsibility on the part of price reporters. If they are to serve buyers and sellers equally, reports should be neutral and objective.

* ———
1957. THE MIDSOUTH'S MULTIPLYING PULPWOOD DOLLARS. South. Pulp and Paper Mfr. 20(9): 44, illus.
Summarizes annual prices for delivered pulpwood, 1937-1956. During 1956, the pulpwood industry in the Midsouth paid out $140,000,000 for pulpwood, as against $5,000,000 in 1937.

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1958. CHIPS BOLSTER MIDSOUTH PULPWOOD CUT IN 1957. South. Pulp and Paper Mfr. 21(10-A): 28, 30, illus. *Also in* Timberman 60(6): 69. 1959.
Charts production of chipped sawmill residues from a start in 1953 to ¾ million cords in 1957. The average 1957 price per ton of green chips was $6.19 for pine and $4.31 for hardwood. Prices for rough bolts are listed also.

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1958. THE ECONOMICS OF TYPE CONVERSION. Gulf States Sect. Soc. Amer. Foresters Proc. 1958: 9-14.
Outlines a method by which the returns from regenerating difficult areas may be compared with other investment opportunities in and out of the forest enterprise. When properly evaluated, seemingly high conversion costs often prove justifiable.

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1960. GUIDELINES FOR THE FOREST INVESTOR. Forest Farmer 19(8): 6-7, illus. *Also in* Forest Farmer (Eighth Manual ed.) 19(7): 47-48, illus. *Also in* (Ninth Manual ed.) 20(7): 89-90, illus. 1961.
Rates of return from investments in planting loblolly pine, under various assumptions as to site and stumpage prices.

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1961. WHAT, WHERE, AND WHEN TO SELL TREES. Prog. Farmer (Tex.-Okla. ed.) 76(5): 30, illus.
Brief hints for owners of small woodlands.

* ———
1961. WHO'S GOING TO USE ALL THIS WOOD? *In* Advances in Management of Southern Pine. La. State Univ. Tenth Ann. Forestry Symposium Proc. 1961: 105-112, illus.
"As our economy limps into the 60's, some disheartened foresters are conjuring up visions of excessive wood supplies. Are they right? I hope to provide a basis for drawing your own conclusions."

* GUTTENBERG, SAM, and CHRISTOPHER, J. F.
1959. MIDSOUTH PULPWOOD CUT RISES IN 1958. South. Pulp and Paper Mfr. 22(8): 58, illus.
Though the Midsouth's 1958 pulpwood harvest set a record, prices for pine bolts were about the same as in 1957, while hardwood bolt prices eased somewhat. Chipped mill residues averaged $6.22 per ton for pine and $4.10 for hardwood.

——— and PERRY, J. D.
1957. PULPWOODING WITH LESS MANPOWER. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 154, 34 pp., illus.
Labor requirements of several systems of pulpwooding in various timber types of Arkansas and Mississippi.

* ——— and PERRY, J. D.
1959. TIMBER BUYERS OF THE YAZOO-LITTLE TALLAHATCHIE WATERSHED OF MISSISSIPPI. South. Forest Expt. Sta., 26 pp., illus.
Directory of 273 timber-buying firms that are active in this 19-county area of north-central Mississippi.

* ——— and ROW, CLARK.
1961. MARKETS, TIMBER QUALITY INFLUENCE SOUTHERN PINE STUMPAGE PRICES. Timberman 62(10): 66-67, 69, illus.
The wholesale lumber market and the quality of the trees largely determine prices bid for pine sawtimber from national forests in Texas, Louisiana, and Mississippi.

* MCDERMID, R. W., KITT, P. D., and GUTTENBERG, SAM.
1959. OWNERSHIP FACTORS AFFECTING MANAGEMENT OF SMALL WOODLANDS IN ST. HELENA PARISH, LOUISIANA. La. Agr. Expt. Sta. and La. State Univ. and Agr. and Mech. Col. Bul. 520, 19 pp., illus.
Landowners who undertake management programs do so on tracts of above-average size and stocking and appear to have more financial resources than the nonmanagers. Many nonmanagers either were unacquainted with the potentialities of forestry, or thought they had a superior use for their forest land.

MIGNERY, A. L.
1956. FACTORS AFFECTING SMALL-WOODLAND MANAGEMENT IN NACOGDOCHES COUNTY, TEXAS. Jour. Forestry 54: 102-105.
The relatively few landowners who have undertaken timber management did so on properties that were reasonably well stocked. They had income from other sources and therefore were not pressed to cut immature growing stock. Even so, they did not undertake timber management until professional foresters encouraged them.

* PERRY, J. D.
1958. MARKETING—AN AVENUE TO REVENUE FROM FARM FORESTS. U. S. Forest Serv. South. Forest Expt. Sta., 5 pp.
Owners of farm forests can benefit greatly from professional help in marketing wood to best advantage. Products research is of great benefit also, through its indirect effect of improving the general market situation.

* ——— and GUTTENBERG, SAM.
1959. SOUTHWEST ARKANSAS' SMALL WOODLAND OWNERS. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 170, 14 pp., illus.
Active managers, while comprising less than 10 percent of the owners, hold one-third of the forested acreage. Those who tend to invest in forestry have above-average assets. Instead of contributing their own time, they typically hire labor for forest operations. Planting open areas to pine and removing undesirable trees are the most popular practices.

* PLEASONTON, ALFRED.
1957. UPLAND HARDWOOD MANAGEMENT APPEALS TO WEST TENNESSEANS. South. Lumberman 195(2441): 108-110, illus.
Of 40 landowners in Hardeman County, 29 are actively interested in managing their hardwoods conservatively—a tribute to years of effort by public and industrial foresters. A few have well-developed programs, but most will need considerable technical advice to advance beyond the elementary stage they have already reached.

* ———
1958. PLANNING FARM-AND-FOREST MANAGEMENT. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 116.
Synopsis of the bulletin by Barraclough and Pleasonton, listed above.

* ——— and GUTTENBERG, SAM.
1961. STIMULATING WOODLAND MANAGEMENT IN NORTH MISSISSIPPI: AN APPRAISAL. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 185, 18 pp., illus.
The eroded Yazoo-Little Tallahatchie watershed of Mississippi is the setting for the largest land-rehabilitation project in the Nation. The program has encouraged landowners to improve their woodlands. Those with above-average assets responded best, but low-income owners also participated.

* ROW, CLARK.
1960. SOUTH'S MARKETS HELP SOUTHERN PINE. South. Lumberman 201 (2503): 26-27, illus.
Recent distribution patterns indicate that the increasing home market for southern pine lumber has offset a continuing decline of shipments to historic markets in the North. In both local and long-distance shipments the preference is for trucks over railroads. Douglas-fir shipments into the South have been stabilized for several years.

* ———
1961. SEASONS SET PACE FOR ACTIVITY IN THE LUMBER BUSINESS. Lumberman 88(1): 26-28, illus.
Lumber production, distribution, and use have different but interrelated yearly cycles. Brisk during warm months and slack in winter, residential construction determines trends in retail sales and orders received by sawmills. Though production also is affected by weather, it is often out of phase with shipments, thus causing fluctuations in inventory and price. In winter, sales are typically low and inventories rise; from April through summer, shipments exceed production, so that mill inventories are at their lowest by October. Temperate southern weather makes output and use of southern pine more uniform than that of western pine or Douglas-fir.

* ———
1961. WILL SOUTHERN PINE EXPORTS REVIVE? South. Lumberman 203(2537): 109-111, illus.
Exports now are a small fraction of those in the days of old-growth timber, but increasing European prosperity, lessened trade restrictions, and economic growth in Latin America may improve them.

* ——— and GUTTENBERG, SAM.
1961. WHY PULPWOOD STUMPAGE PRICES VARY. Pulpwood Prod. 9(10): 14, 16, illus.
Prices of pine pulpwood stumpage from national forests in the Midsouth are highest near the Alabama-Mississippi Gulf Coast and decline toward the west and north. Most variation is related to the number of companies competing for wood, general demand for pine roundwood, size and density of the timber, and types of wood included in the sale.

HARVEST AND MANUFACTURE

* BOWER, D. R.
1961. ARE SCALES BETTER THAN SCALE STICKS? South. Lumberman 203(2530): 38, illus.
Analysis of 902 truckloads of loblolly pine logs confirmed the feasibility of weight-scaling. The article lists weights per MBF for logs of various diameters and offers advice for mill owners who wish to begin weight-scaling.

* BRUCE, H. D., and FASSNACHT, D. L.
1958. WOOD HOUSES CAN BE FIRE-SAFE HOUSES. Forests and People 8(4): 16-17, 44, illus.
Performance of wood in a fire compares well with that of other materials.

* CARPENTER, B. E., JR.
1959. BOLTS SALVAGED FROM CULL OAKS? South. Lumberman 199(2484): 30-31, illus.
Describes an attempt to determine if bolts from low-grade hardwoods can be profitably harvested and sawn into blanks for furniture manufacture.

* FASSNACHT, D. L.
1956. BOARDS OR CHIPS? South. Lumberman 193(2417): 243-244, illus.
If the mill owner knows his net return per MBM of low-grade lumber and per ton of chips, and the average weight per cubic foot of the wood he is sawing, he can use the tables and charts in this article to decide whether he should saw his knotty center cants or make them into pulp chips.

GAMMAGE, J. L., and FURNIVAL, G. M.
1957. CHEMICAL DEBARKING IN BOTTOMLAND HARDWOODS. South. Pulp and Paper Mfr. 20(9): 78, 80, illus.
Sodium arsenite was painted on a 6-inch bole section from which the bark had been removed. Reaction varied with species, but all species could be peeled as quickly 3 to 6 months after treatment as during the spring.

GRAHAM, W. L.
1955. CARRYING CASE FOR CHAIN SAW. U. S. Forest Serv. Fire Control Notes 16(3): 7, illus.
Construction details.

* GUTTENBERG, SAM.
1956. HAND-LOADING DAYS ARE ABOUT GONE. Pulpwood Prod. 4(7): 14, 30, illus
Mechanized woodyards for receiving pulpwood and transferring it from motor truck to railroad car are becoming more numerous. A yard at Canton, Mississippi, is saving 65,000 man-hours and 5,000 truck-hours yearly for the producers who haul pulpwood to it.

———
1957. TRAILERS GIVE WOODYARDS LONG REACH. Pulpwood Prod. 5(8): 18-20, illus
Detachable trailers, capable of carrying more than 7 cords, are replacing single-axled trucks for pulpwood hauling. The development of inexpensive machines for loading and unloading bolts has contributed to the use of these big trailers.

———
1957. WOODYARD EARNS PLACE IN INDUSTRY. Pulpwood Prod. 5(1): 48-50, 52.
Woodyards reduce the number of man-hours required to cut and deliver pulpwood and offer a place where less-than-carload lots may be delivered and sold.

———
1958. COST CONTROL, AT LOW COST. Pulp and Paper 32(7): 99-101, illus.
Offers a simple graphic method by which pulpwood producers can analyze their logging costs, and indicates the need for more sophisticated analysis.

———
1959. MECHANIZED YARD TREND IN PULPWOOD HANDLING. Timberman 60(6): 56-57, illus.
See second entry above.

——— FASSNACHT, D. L., and SIEGEL, W. C.
1960. WEIGHT-SCALING SOUTHERN PINE SAW LOGS. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 177, 6 pp., illus.
In a Louisiana study, log-to-lumber predictions were closer when based on weight of the logs than when derived from values of conventional log rules.

* ——— and PERRY, J. D.
1957. WEIGHT-CONSCIOUS LUMBERMEN. South. Lumberman 195(2430): 54, 56, illus.
The choice between making a log into lumber or chips depends on (1) the net value of chips recoverable from low-grade log centers and short jacket lengths before the extra lines are sawn, and (2) the lumber values in these same log portions adjusted for the extra sawing and handling costs involved in producing finished lumber.

* HEDLUND, ARNOLD.
1959. LOOK AT THE SCARS! South. Lumberman 199(2489): 225-226, illus.
Amount of cull in hardwood butt logs can be estimated directly in the field if local correlations of scar length and cull volume have been established.

KINABREW, R. G.
1960. MARKETING NORTH MISSISSIPPI HARDWOOD: PRIME QUALITY AND SPECIALTY TYPES. U. S. Forest Serv. South. Forest Expt. Sta. and Univ. Miss., 56 pp., illus.
The Memphis hardwood market is economically accessible by truck or rail to timber producers in the western half of north Mississippi. In 1960, prime and specialty material was bringing prices that assured profitable marketing from distances of at least 100 miles.

* MUNTZ, H. H.
1956. TRACTOR TILT INDICATOR. U. S. Forest Serv. Fire Control Notes 17(3): 4.
The indicator is a plumb bob that swings from the hood above the instrument panel and registers the degree of tilt on a color-coded scale.

* PERRY, J. D.
1957. THE CONCENTRATION-YARD INDUSTRY IN NORTH GEORGIA. Jour. Forestry 55: 451-453.
The typical concentration yard purchases, finishes, and markets lumber from portable sawmills whose output is too small to be placed advantageously on the Nation's market. The number of yards and portable mills in north Georgia has been decreasing, but the yard-mill combination is likely to be useful for some years more.

PUTNAM, J. A.
1960. BASIC DIFFERENCES IN GRADING HARDWOOD AND SOFTWOOD SAWTIMBER. Soc. Amer. Foresters Proc. 1959: 57-62, illus.

" . . . The essential requirements of their predominant end-product uses lead to contrasting criteria for and methods of grading for hardwood and softwood timber."

RICHARDS, D. B.
1958. HIGH TEMPERATURE DRYING OF SOUTHERN HARDWOODS. Ala. Agr. Expt. Sta. Cir. 123, 12 pp., illus.

At 110°C., yellow-poplar, beech, blackgum, hickory, and sap sweetgum were dried in a short time without excessive visible defect. Hygroscopicity was noticeably decreased, but mild collapse occurred. Red oak, white oak, and sweetgum heartwood displayed severe internal checking.

* SIEGEL, W. C., and ROW, CLARK.
1960. SELLING SAWLOGS BY THE TON. Forest Farmer 19(13): 8-9, illus. *Also in* Forest Farmer (Ninth Manual ed.) 20(7): 127-128, illus. 1961. *Also in* (Tenth Manual ed.) 21(7): 123-124, illus. 1962.

Weights of logs of various diameters, lengths, and volumes, and factors for estimating board-foot content of truckloads whose weight is known.

* WRAY, CLAYTON, and MIGNERY, A. L.
1959. SOIL COVERS IMPROVE AIR-DRYING OF RED OAK. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 124.

When the ground under conventional lumber stacks was covered with roofing paper, losses of FAS by shrinkage and degrade were halved.

MEASUREMENT

* AVERY, GENE.
1957. FORESTER'S GUIDE TO AERIAL PHOTO INTERPRETATION. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 156, 41 pp., illus.

Sources and procurement of photos, preparation for use, and application in area measurement, type mapping, and volume estimation.

* ———
1958. COMPOSITE AERIAL VOLUME TABLE FOR SOUTHERN PINES AND HARDWOODS. Jour. Forestry 56: 741-745, illus.

This study, in northeast Mississippi, indicated that composite tables can yield estimates of mean cubic volume per acre within 10 percent of actual field volume when photo measurements of total height, crown diameter, and crown closure can be reliably determined. Crown closure is the most difficult of the three variables to evaluate.

* ———
1958. EASY AS P. I.! South. Lumberman 197(2465): 109-111, illus.

Multiple-choice test on identification of objects on aerial photos.

* ———
1958. HELICOPTER STEREO-PHOTOGRAPHY OF FOREST PLOTS. Photogrammetric Engin. 24: 617-624, illus.

Good stereo-pairs were obtained on panchromatic film at altitudes of 200 and 300 feet, and on color transparencies at 300 feet. Helicopter stereograms were slightly superior to 1:20,000 prints for determining average total tree heights and average tree-crown diameters. Use of color transparencies did not improve accuracy of measurement for these variables. Crown-closure estimates proved independent of photo scale, but panchromatic photography gave better results than color.

* ———
1958. SLOTTED CLIP BOARD FOR VIEWING AERIAL PHOTOS. Univ. Minn. Forestry Notes 63, 2 pp., illus.

The board facilitates study of overlapping area of 9- by 9-inch stereo pairs, as it allows interfering portions of the prints to be bent downward and out of the way.

* ———
1959. EVALUATING UNDERSTORY PLANT COVER FROM AERIAL PHOTOGRAPHS. Techniques and Methods of Measuring Understory Vegetation, pp. 82-83. U. S. Forest Serv. South. and Southeast. Forest Expt. Stas.

Understory plants cannot be viewed directly on 1:20,000 aerial photographs, but assessment of plants in the dominant canopy should be useful for distributing plots for ground measurement and for predicting the composition and character of minor vegetation.

———
1959. PHOTOGRAPHING FORESTS FROM HELICOPTERS. Jour. Forestry 57: 339-342, illus.

Helicopters are well adapted to taking large-scale, low-altitude aerial photos of forest areas. To offset flying costs, however, such photos must yield information not obtainable from conventional 1:20,000 prints.

* ——— and MYHRE, D. W.
1959. COMPOSITE AERIAL VOLUME TABLE FOR SOUTHERN ARKANSAS. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 172, 9 pp., illus.

Construction and application of table for mixed pines and hardwoods. Volumes, expressed in gross cubic feet per acre, are derived from stereoscopic measurements of average tree heights and crown closure percent. Also included is a table for converting differential parallax measurements in millimeters to tree heights in feet.

* BEAUFAIT, W. R., and NELSON, T. C.
1957. RING COUNTS IN SECOND-GROWTH BALDCYPRESS. Jour. Forestry 55: 588, illus.

Thrifty, second-growth baldcypress trees often appear to lay down several rings each year, but when increment-borer cores are sectioned and examined under a magnification of 20 diameters or more the true summerwood appears clearly as narrow bands of small, thick-walled cells.

* BRUCE, DAVID.
1955. A NEW WAY TO LOOK AT TREES. Jour. Forestry 53: 163-167, illus.

Prisms are compact, convenient instruments for cruising timber by the point-sampling technique.

* ECHOLS, R. M.

1959. ESTIMATION OF PULP YIELD AND QUALITY OF LIVING TREES FROM PAIRED-CORE SAMPLES. TAPPI 42: 875-877, illus.

To reduce variation from causes such as eccentricity and compression wood, pairs of samples for specific gravity and ring width measurements are taken from opposite sides of trees, and include all growth rings from pith to bark. Measurements are converted to estimated pulp yield to derive wood-quality index values.

* ———— and BOWDEN, A. B.

1961. INEXPENSIVE RING ANALYZER FOR CUMULATIVE SUMMERWOOD MEASUREMENTS. Forest Sci. 7: 147-148, illus.

A wooden holder, moving on threaded rods, for positioning increment cores under a microscope.

* FARRAR, R. M., JR.

1961. SECTOR FORK VERSUS CALIPERS OR TAPE. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 136.

A test with longleaf pine in south Alabama indicated that the Bitterlich sector fork may be used for tree diameter measurements when accuracy of about ± 0.7 inch is acceptable.

FASSNACHT, D. L.

1955. GRID SYSTEM FOR RANDOMIZED BLOCK LAYOUT. Jour. Forestry 53: 34-35, illus.

A simple layout that uses experimental areas efficiently and simplifies the establishment and monumentation of plots.

* FREESE, FRANK.

1959. DESK CALCULATOR OR ELECTRONIC COMPUTER? Techniques and Methods of Measuring Understory Vegetation, pp. 127-132. U. S. Forest Serv. South. and Southeast. Forest Expt. Stas.

Use of electronic data-processing machines will tend to standardize vegetation-survey techniques and to encourage adoption of quantitative measures of vegetational characteristics. But these machines are more efficient than hand calculators only for problems that can be clearly defined, are mathematical in nature, and involve a heavy computational load.

* ————

1960. TESTING ACCURACY. Forest Sci. 6: 139-145.

Testing the accuracy of a measurement against an accepted standard calls for a statement of the accuracy required, a measure of the accuracy attained, and an objective method of deciding whether attained accuracy is equal to required accuracy. All three criteria are met by the standard chi-square test. The t-test is unsuitable because it uses one form of accuracy, precision, to test for another form, freedom from bias.

* ————

1961. RELATION OF PLOT SIZE TO VARIABILITY: AN APPROXIMATION. Jour. Forestry 59: 679.

If the coefficient of variation (CV_1) among plots of size P_1 is known, the coefficient (CV_2) for plots of some other size (P_2) can often be approximated from the relationship

$$(CV_2)^2 = (CV_1)^2 \sqrt{\frac{P_1}{P_2}}$$

* GROSENBAUGH, L. R.

1955. BETTER DIAGNOSIS AND PRESCRIPTION IN SOUTHERN FOREST MANAGEMENT. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 145, 27 pp., illus.

It is generally undesirable, especially in the southern Coastal Plain, to regard stands as units of management or inventory. Instead, areas with meaningful, permanent boundaries and convenient working size should be established as the minimum unit for records and management prescriptions. Some tree-classes are defined to aid in prescription and assignment of management priorities. A simplified point-sampling scheme with a special tally form for collecting silvicultural data is described.

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1956. TRICKS IN SAMPLING TREE VOLUME. La. State Univ. Fifth Ann. Forestry Symposium Proc. 1956: 85-92, illus.

Four techniques for estimating board-foot volume of trees: (1) summing merchantable heights of trees point-sampled with a 104.18-minute angle gauge and multiplying by a factor; (2) a formula in terms of d.b.h. and number of 16-foot logs which can be worked out mentally; (3) a giant-tree table; and (4) the height-accumulation method.

* ————

1958. ALLOWABLE CUT AS A NEW FUNCTION OF GROWTH AND DIAGNOSTIC TALLIES. Jour. Forestry 56: 727-730.

Discusses (1) need to gear allowable cut to actual growth and ultimate levels of growing stock desired; (2) advantage of straight-line (simple interest) projection of forest stands; (3) advantages of a new allowable-cut formula utilizing simple annual growth rates and setting forth goals and assumptions explicitly; (4) need for permanent point-samples or plot-samples to provide feedback information; (5) importance of periodic coverage of all record-units by a cheap but valuable diagnostic tally primarily silvicultural in objective but useful in crystallizing marking prescriptions and in allocating allowable cut and available funds.

* ————

1958. GIANT-TREE VOLUMES FOR MACHINE USE. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 117.

Formulae for electronic calculation of sectional tree volumes as a function of length. A constant taper of 2 inches in 16 feet is assumed.

* ————

1958. POINT-SAMPLING AND LINE-SAMPLING: PROBABILITY THEORY, GEOMETRIC IMPLICATIONS, SYNTHESIS. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 160, 34 pp., illus.

Explains new theory of sampling forest trees with probability proportional to some element of tree size, gives underlying statistical and geometric bases, discusses possible sources of bias and how to avoid them, and synthesizes theories into techniques for efficient application.

* ————

1958. THE ELUSIVE FORMULA OF BEST FIT: A COMPREHENSIVE NEW MACHINE PROGRAM. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 158, 9 pp., illus.

Outlines use of a new and completely self-contained multiple regression program developed for the IBM 704. The program gives coefficients, constants, and regression sums of squares for all possible regressions involving linear combinations of 9 or fewer independent variables. It will accept as input either a matrix from any number of sets of observations or raw data from 500 or fewer sets of observations. Cost of processing is very moderate, considering that as many as 511 different regressions are given.

GROSENBAUGH, L. R.
1959. POINT-SAMPLING TAPES AND CLINOMETERS NOW COMMERCIALLY AVAILABLE. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 121.
Specially graduated 100-foot tapes have been designed and manufactured to enable speedy field check of trees doubtfully "in" or "out" of point-sample tally with a BA factor of either 10 or 75.625. Also available are specially graduated clinometers that read directly both maximum slope and the multiplier appropriate to all per-acre estimates made at any point on that slope.

* ———
1960. QUANTIFICATION AND ESTIMATION IN FUTURE FOREST MANAGEMENT. Soc. Amer. Foresters Proc. 1959: 117-121.
How forest management of the future may overcome complications attributable to space, time, and stand structure; what advances in devising appropriate scales and instruments may be anticipated; and how the problem of correlating product-yield with standing tree measurements may be met. Potential contributions of air transport, high-speed computers, electronic devices, and statistical theory are briefly outlined.

* ———
1960. SHOULD CONTINUITY DOMINATE FOREST INVENTORIES? Short Course in Continuous Inventory Control in Forest Management Proc., pp. 74-83, illus. Univ. of Ga. Center for Continuing Education.
Forest management objectives require at least 3 kinds of inventory: permanent samples for estimates of growth or trend, ephemeral samples for diagnosing area needs and priorities, and product-outturn samples for relating standing tree classes to end-product quality or values. Permanent plots are useful only for growth estimates. Point-sampling can be efficiently used for all 3 objectives. Illustrates simple point-sampling computations for permanent point-samples and for cheap diagnostic tallies.

* ———
1961. OF TREES, SPACE, TIME, AND KNOTS. Ia. State Univ. Forestry Club, Ames Forester 48: 20-23.
At least 7 different classes of variables affecting timber quality can be recognized, but the relative importance of each and the optimum condition vary with the given end-product. Some aspects of quality are technological and abrupt—unacceptable end-products are derived from timber below certain quality thresholds. Other aspects are economic and continuous—costs eat into profits as quality gradually drops. Silviculture affects quality of existing stands largely through allocation of growing space, selection of stems for retention, length of rotation, and pruning. A prognosis of the impact of quality considerations on southern silviculture is made.

* ——— and STOVER, W. S.
1957. POINT-SAMPLING COMPARED WITH PLOT-SAMPLING IN SOUTHEAST TEXAS. Forest Sci. 3: 2-14.
With a wedge-prism point-samples were taken concentric with quarter-acre plot-samples at 655 locations in 12 counties of east Texas. Differences between the two types of sample were only 1/10 of 1 percent for basal area and total cubic volume, and 1.1 percent for sawlog volume—well within limits attributable to sampling variation alone.

* MESAVAGE, CLEMENT.
1961. EXPLORATORY RELATIONS OF STAND GROWTH TO MEASURABLE ELEMENTS OF STAND STRUCTURE. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 182, 4 pp.
The Southern Station's IBM 704 Regression Program was used to select equations for predicting basal-area growth of shortleaf pine over a two-year span.

——— and GROSENBAUGH, L. R.
1956. EFFICIENCY OF SEVERAL CRUISING DESIGNS ON SMALL TRACTS IN NORTH ARKANSAS. Jour. Forestry 54: 569-576, illus.
Plots of 0.1-acre or less tended to be more efficient than larger plots except where a very sparse tree population was being sampled. An equispaced arrangement of plots tended to be more efficient than any other. Techniques for assessing precision and efficiency of various plot sizes and plot arrangements are illustrated.

* ——— and SMITH, W. S.
1960. TIMESAVERS FOR INSTALLING DENDROMETER BANDS. Jour. Forestry 58: 396, illus.
A stamp for impressing a 3-inch scale on an aluminum band.

* MYHRE, D. W., and MEYER, M. P.
1961. TREE IMAGE RECOVERY ON AERIAL PHOTOGRAPHS AS AFFECTED BY PRINTING METHOD AND FILM. Jour. Forestry 59: 97-99, illus.
In medium-scale aerial photography of northern Minnesota forests, little difference was found between full-scan electronic prints and conventional contact prints. Tree-crown recovery was better on panchromatic than on infrared photography.

* SAND, N. H.
1957. REVOLUTION IN TIMBER CRUISING. Amer. Forests 63(4): 32-34, 66-67, illus. *Also as* DIE WINKELZÄHLPROBE IN AMERIKA. Holz-Kurler 12 (23). Transl. Dr. W. Bitterlich.
After the Austrian forester Walter Bitterlich conceived the basic idea of "variable plot radius" for measuring the basal area of forest stands, L. R. Grosenbaugh developed the idea into a complete theory. The use of prisms for angle-gauges enhanced the practicality of the method, and a Forest Survey trial in east Texas proved its inherent accuracy.

* THAMES, J. L., and URSIC, S. J.
1959. PRECISE TEMPERATURE CONTROL WITH THERMOCOUPLES. Agr. Engin. 40: 401-402, illus.
Control within ± 0.3° F. was obtained with an easily assembled arrangement of a portable potentiometer and an inexpensive photoelectric circuit.

TOOLE, E. R., and GAMMAGE, J. L.
1959. DAMAGE FROM INCREMENT BORINGS IN BOTTOMLAND HARDWOODS. Jour. Forestry 57: 909-911, illus.
Though the borer holes callused over in 2 years, the stain that developed around most of them would constitute a defect in logs intended for factory lumber or veneer. Some holes had rot infections.

URSIC, S. J., and MCCLURKIN, D. C.
1959. SMALL PLOTS FOR MEASURING VEGETATION COMPOSITION AND COVER. Techniques and Methods of Measuring Understory Vegetation, pp. 70-78. U. S. Forest Serv. South. and Southeast. Forest Expt. Stas.
Guidelines for determining optimum shape, size, number, and distribution of sample plots.

RANGE

BOYER, W. D.

1958. LONGLEAF PINE ESTABLISHMENT AND FIRST-YEAR SURVIVAL UNAFFECTED BY MODERATE GRAZING. Jour. Forestry 56: 655.

Cattle stocking was 1 cow for 60 acres of Alabama forest range; utilization averaged 22 percent. The grazing had a negligible effect on seedling establishment and first-year survival, but sustained heavy grazing before seedfall may be harmful.

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1958. LONGLEAF SEEDLINGS ENDURE MODERATE GRAZING. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 113.

See preceding entry.

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1959. HARVESTING AND WEIGHING VEGETATION. Techniques and Methods of Measuring Understory Vegetation, pp. 11-16. U. S. Forest Serv. South. and Southeast. Forest Expt. Stas.

Though the weight method of sampling herbage is laborious, it is highly useful both in research and in range and pasture management.

* CAMPBELL, R. S.

1955. INTEGRATION OF GRAZING AND TIMBER PRODUCTION IN THE DEEP SOUTH. Soc. Amer. Foresters Proc. 1954: 199-201.

Cattle grazing promises to continue as a permanent use of forest land in the longleaf-slash pine belt. If properly managed, cattle will do little damage to pine regeneration, and they will utilize grass and other forage that might otherwise feed wildfires.

* ———

1955. VEGETATIONAL CHANGES AND MANAGEMENT IN THE CUT-OVER LONGLEAF PINE-SLASH PINE AREA OF THE GULF COAST. Ecol. 36: 29-34, illus.

The secondary plant succession is being influenced by timber cutting, burning, and grazing. The increasing intensity of land management is also raising problems concerning the fertility and physical condition of forest soils.

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1957. GRAZING IN SOUTHERN PINE FORESTS. La. State Univ. Sixth Ann. Forestry Symposium Proc. 1957: 13-20.

" . . . Much of our Coastal Plain forest land will be grazed by livestock for years to come . . . . With the forester's interest and cooperation, much better integration of timber growing, livestock grazing, and game habitat can be achieved."

———

1959. THE IMPORTANCE OF UNDERSTORY MEASUREMENT IN FOREST AND RANGE RESEARCH. Techniques and Methods of Measuring Understory Vegetation, pp. 2-3. U. S. Forest Serv. South. and Southeast. Forest Expt. Stas.

Purpose, scope, and organization of the U. S. Forest Service Conference on Techniques and Methods of measuring Understory Vegetation, held at Tifton, Georgia, October 27-31, 1958.

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1960. USE OF FIRE IN GRASSLAND MANAGEMENT. Prepared for FAO First Working Party on Pasture and Fodder Development in Tropical America, Maracay, Venezuela, October 1960. 10 pp., Spanish summary.

Damages caused by wildfire, uses of planned fires and procedure for conducting them.

——— and CASSADY, J. T.

1955. FORAGE WEIGHT INVENTORIES ON SOUTHERN FOREST RANGES. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 139, 18 pp., illus.

Specific instructions for inventorying forage on cattle and deer ranges.

CASSADY, J. T.

1955. GRAZING ON FOREST LAND. Forest Farmer Manual. Ed. 3, pp. 144-146, illus. *Also in* Ed. 4, pp. 144-146, illus. 1956. *Also in* Ed. 5, pp. 128-129, illus. 1957. *Also in* (Sixth Manual ed.) 17(7): 132-133, illus. 1958. *Also in* (Seventh Manual ed.) 18(8): 126-127, illus. 1959.

Properly managed herds will cause essentially no damage to the timber or watershed. Generally, forest grazing should be limited to the Coastal Plain, especially the longleaf-slash pine belt.

———

1955. SHOULD PINE WOODS BE GRAZED? Prog. Farmer (Tex. ed.) 70(6): 32, 127, illus.

Practical advice on carrying capacity of forest ranges, methods of herd management, and ways of avoiding damage to pines.

———

1959. GENERAL REVIEW OF METHODS AND TECHNIQUES FOR MEASURING PRODUCTION AND UTILIZATION. Techniques and Methods of Measuring Understory Vegetation, pp. 5-10. U. S. Forest Serv. South. and Southeast. Forest Expt. Stas.

"The trend . . . has been from the extensive to the intensive, from estimates to direct measurements or to measurements supplemented by carefully checked estimates. In general, techniques are becoming more efficient and more direct."

——— HOPKINS, WALT, and WHITAKER, L. B.

1955. CATTLE GRAZING DAMAGE TO PINE SEEDLINGS. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 141, 14 pp., illus.

Observations in central Louisiana suggest that some damage can be expected when cattle graze an area during the first few years after it has been seeded or planted to pine. If grazing is permitted in such young stands, it should not start before May 1, and should be regulated so that not more than half of the green forage is used during the entire season.

——— and WHITAKER, L. B.

1957. SUPPLEMENTAL FEEDING AND MANAGEMENT OF BEEF CATTLE ON FOREST RANGE IN LOUISIANA. Soc. Amer. Foresters Proc. 1956: 52-54.

Supplemental feeding, together with good herd and range management, improved the weight and condition of the cows, and increased the calf crop and the market weight of the calves.

* DUNCAN, D. A.

1958. TRACE MINERALS AMPLE ON WOODS RANGE. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 117.

See Duncan and Epps, 1958, La. Agr. Expt. Sta. Bul. 516.

DUNCAN, D. A.
1959. WEIGHT METHODS FOR MEASURING HERBAGE UTILIZATION. Techniques and Methods of Measuring Understory Vegetation, pp. 32-35. U. S. Forest Serv. South. and Southeast. Forest Expt. Stas.
Clipping and weighing is accurate but laborious. Methods involving measurements of plant weight and relations of height to weight are less accurate but faster.

* ———— and EPPS, E. A., JR.
1958. MINOR MINERAL ELEMENTS AND OTHER NUTRIENTS ON FOREST RANGES IN CENTRAL LOUISIANA. La. Agr. Expt. Sta. Bul. 516, 19 pp., illus.
Longleaf pine-bluestem native forest ranges in central Louisiana seem to contain ample trace minerals for cattle nutrition. Of major nutrients, potassium is abundant and calcium is adequate, but phosphorus is deficient at all seasons and crude protein is seriously lacking except in spring and early summer.

———— and EPPS, E. A., JR.
1958. MINOR MINERALS AND OTHER NUTRIENTS IN LOUISIANA RANGE FORAGE. Jour. Range Mangt. 11: 247-248.
See preceding entry.

———— and EPPS, E. A., JR.
1959. WHAT SUPPLEMENTS ARE NEEDED ON FOREST RANGE? Gulf Coast Cattleman 25(9): 33-34.
See second entry above.

* ———— and WHITAKER, L. B.
1958. A NEW LOOK AT THE POSSIBILITIES OF FOREST RANGES AND RANGE CATTLE IN LOUISIANA. Forests and People 8(2): 26-28, 48-49, illus.
A program of supplemental feeding, coupled with good herd and range management, doubled the productivity of cattle grazing on forest range.

———— and WHITAKER, L. B.
1959. CATTLE REPELLENTS FOR PLANTED PINES. U. S. Forest Serv. Tree Planters' Notes 36, pp. 9-12, illus.
A mixture of copper carbonate and asphalt emulsion is effective and economical.

* ———— and WHITAKER, L. B.
1959. REPELLENTS REDUCE CATTLE BROWSING ON PINES. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 119.
See preceding entry.

* DUVALL, V. L., and WHITAKER, L. B.
1959. NOW! A CATTLE REPELLENT FOR PINES. Forests and People 9(4): 32-33, 46, illus.
See second entry above.

GRELEN, H. E.
1959. THE BASAL AREA METHOD FOR MEASURING GROUND COVER. Techniques and Methods of Measuring Understory Vegetation, pp. 45-47. U. S. Forest Serv. South. and Southeast. Forest Expt. Stas.
In ecology; basal area refers to ground cover at a height of one inch; basal-area measurements give reliable indications of vegetational change or range trend.

* HALLS, L. K.
1959. COORDINATION OF CATTLE GRAZING AND TIMBER GROWING ON SOUTHERN COASTAL PLAIN FORESTS. Soc. Amer. Foresters Proc. 1958: 192-195, illus.
"Coordination . . . encompasses a multitude of factors ranging from personal attitude and managerial ability to basic understanding of the reproduction, growth, and management of livestock, forage, and timber."

* ———— and DUVALL, V. L.
1961. PROFITS AND COST OF FOREST GRAZING. Forest Farmer (Ninth Manual ed.) 20(7): 151-152, illus. *Also in* (Tenth Manual ed.) 21(7): 149-150, illus. 1962. *Also in* Gulf Coast Cattleman 27(7): 5-6, illus. 1961.
On longleaf pine-bluestem ranges of Louisiana and east Texas, outlay per cow may be about $285 for investment and $49 annually for operating. A well-managed herd should average 6 to 10 percent on the investment.

* ———— HUGHES, R. H., and PEEVY, F. A.
1960. GRAZED FIREBREAKS IN SOUTHERN FORESTS. U. S. Dept. Agr. Agr. Inform. Bul. 226, 8 pp., illus.
Guide to the establishment and maintenance of grazed firebreaks. These strips of improved pasture aid in fire protection and provide forage for livestock and game.

* ———— READ, R. A., and CRAWFORD, H. S., JR.
1960. FORAGE AND GROUND-COVER CONDITIONS IN UNMANAGED OZARK FORESTS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forest Res. 1: 1-6, illus.
Minimal grazing and control of fire from 1947 to 1957 bettered ground-cover conditions but not forage values. Understory vegetation fluctuated from year to year, being influenced chiefly by distribution of rainfall. Yield of herbaceous vegetation in the woodlands after 10 years of conservative use was less than one-fifth of that on open meadow.

* JOHNSON, R. L.
1960. CATTLE GRAZING IN DELTA FORESTS. Miss. Farm Res. 23(1): 5, illus. *Also as* Miss. Agr. Expt. Sta. Inform. Sheet 655, 2 pp., illus.
If bottom-land hardwood forests are to be grazed at all, they should be used only for short periods in spring, and then only lightly. Usually the meager returns from the forage will not justify the hazard to the timber.

* MOYLE, R. C.
1956. GRAZING DAMAGE TO LOBLOLLY PINE. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 104.
Damage by cattle and deer was most serious in winter.

PEEVY, F. A.
1957. RESEEDING FOREST RANGES. Prog. Farmer (Miss.-Ark.-La. ed.) 72(3): 171.
Louisiana forest ranges can be reseeded by applying 1,000 pounds of basic slag per acre on a disked site and sowing common or sericea lespedeza in combination with Bahiagrass or carpetgrass.

* ———— and CASSADY, J. T.
1957. CASE FOR THE SEEDED FIREBREAK. Forest Farmer 16(10): 4-5, 16-18, illus.
Recommendations for preparing firebreaks seeded to lespedeza and carpetgrass. If kept closely grazed, such breaks are good firestoppers. They also supplement native forage.

SMITH, L. F., CAMPBELL, R. S., and BLOUNT, C. L.
1955. FORAGE PRODUCTION AND UTILIZATION IN LONGLEAF PINE FORESTS OF SOUTH MISSISSIPPI. Jour. Range Mangt. 8: 58-60, illus.
Forage, mainly little bluestem and slender bluestem, varied from 850 pounds per acre in an open pine stand to 400 pounds under dense timber. Spring was the best grazing season.

* ———— CAMPBELL, R. S., and BLOUNT, C. L.
1958. CATTLE GRAZING IN LONGLEAF PINE FORESTS OF SOUTH MISSISSIPPI. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 162, 25 pp., illus.
Both cattle and timber fared well when forest range was moderately grazed during the spring

and summer. Forest grazing is not recommended in winter.

* STOVER, W. S., and CAMPBELL, R. S.
1955. CATTLE GRAZING IN EAST TEXAS FORESTS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 95.
More than 80 percent of east Texas forest land is grazed.

* WHITAKER, L. B., and DUVALL, V. L.
1960. COMMON-RANGE TECHNIQUE IN SUPPLEMENTAL FEEDING EXPERIMENTS. Jour. Range Mangt. 13: 263.
After 30 days of training, cattle in various experimental groups grazed together as a herd on the range but went to separate pens for protein rations.

* WILLIAMS, R. E., CASSADY, J. T., HALLS, L. K., and WOOLFOLK, E. J.
1955. RANGE RESOURCES OF THE SOUTH. Ga. Agr. Expt. Stas. Bul. (n. s.) 9, 31 pp., illus.
Describes and illustrates the major range types of the South.

WOODS, F. W.
1959. NUTRITIONAL ASPECTS OF WIREGRASS FROM WEST FLORIDA SANDHILLS. Jour. Range Mangt. 12: 141.
Wiregrass was most nutritious in the spring and on burned ranges. At best, crude protein approached minimum estimated requirements for beef cattle, while calcium, magnesium, potassium, and sodium were adequate. Phosphorus was seriously deficient.

WILDLIFE

BLAIR, R. M.
1957. A STEP FORWARD—FOREST GAME HABITAT RESEARCH. Forests and People 7(2): 34-35, 46, 54-55, illus.
Game habitat problems in Louisiana, and a summary of planned habitat studies.

———
1959. WEIGHT TECHNIQUES FOR SAMPLING BROWSE PRODUCTION ON DEER RANGES. Techniques and Methods of Measuring Understory Vegetation, pp. 26-31. U. S. Forest Serv. South. and Southeast. Forest Expt. Stas.
Browse is difficult to inventory. Many weight techniques have been devised, but all are variations of one of three standard procedures: actual measure by clipping and weighing, weight estimates, or a combination of clipping and estimating.

* ———
1960. DEER FORAGE INCREASED BY THINNING IN A LOUISIANA LOBLOLLY PINE PLANTATION. Jour. Wildlife Mangt. 24: 401-405, illus.
The plantation was thinned at ages 20 and 25 years to basal areas of 100, 85, and 70 square feet of pine per acre. By age 29, hardwoods had developed in inverse relation to pine stocking and correspondingly limited growth of understory vegetation suitable for deer. Per-acre yields of palatable browse ranged from 90 pounds under light thinning to 137 under heavy

* BURKE, H. D.
1955. A HOLM FOR GAME. South. Lumberman 191(2393): 190, illus.
Holms are forest areas reserved for game in a forest managed for timber. They can frequently be established at very little cost in parts of the forest that do not fit well into the general management plan.

———
1956. GAME HABITAT AND THE MULTIPLE USE OF SOUTHERN FOREST RANGES. Jour. Range Mangt. 9: 164-166.
Close correlation is needed between timber, wildlife, and game.

* ———
1956. WILDLIFE HABITAT RESEARCH NEEDS IN SOUTHERN FORESTS. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 149, 64 pp., illus.
Information is particularly lacking on the effects of silvicultural practice, season, soil differences, and animal use on the volume and quality of food plants within the major forest types.

* ——— and BLAIR, R. M.
1957. GAME AS A PRODUCT OF INTENSIVELY MANAGED FORESTS. Soc. Amer. Foresters Proc. 1956: 190-191.
The management of forests to include wildlife will require the cooperation of landowners, forest and game managers, researchers, and the public.

* BURNS, R. M.
1957. RABBITS PREFER SWEETGUM TO PINE. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 111.
In north Mississippi, rabbits damaged 10 percent of newly planted gums, 4 percent of shortleaf pines, and 1 percent of slash and loblolly.

CRAWFORD, H. S., JR.
1959. SAMPLING THE PRODUCTION OF FRUITS AND SEEDS OF WOODY AND HERBACEOUS PLANTS. Techniques and Methods of Measuring Understory Vegetation, pp. 116-122. U. S. Forest Serv. South. and Southeast. Forest Expt. Stas.
Factors that influence fruiting and seeding, and methods of sampling production.

———
1961. EASTERN REDCEDAR, JUNIPERUS VIRGINIANA. Deer Browse Plants of Southern Forests, pp. 34-35, illus. U. S. Forest Serv. South. and Southeast. Forest Expt. Stas.
See Halls and Ripley, 1961.

———
1961. IDENTIFYING GREENBRIER GROWTH. Jour. Range Mangt. 14: 42, illus.
On current growth of Smilax bona-nox *L., most persistent leaf bases are brown or light green; on old growth all bases look bleached and papery white.*

GOODRUM, P. D., and HALLS, L. K.
1961. FRINGETREE, CHIONANTHUS VIRGINICUS. Deer Browse Plants of Southern Forests, pp. 10-11, illus. U. S. Forest Serv. South. and Southeast. Forest Expt. Stas.
See Halls and Ripley, 1961.

HALLS, L. K.
1959. WILDLIFE HABITAT RESEARCH IN THE SOUTH: STATUS AND NEEDS. Soc. Amer. Foresters Proc. 1958: 130-133.
Increased pressure for recreational use of forest lands in the South dictates the expansion of research in game habitat. Assessment of wildlife potential requires an objective inventory, analysis, and interpretation of the vegetation.

* HALLS, L. K., and CRAWFORD, H. S., JR.
1960. DEER-FOREST HABITAT RELATIONSHIPS IN NORTH ARKANSAS. Jour. Wildlife Mangt. 24: 387-395, illus.
In a favorable forest habitat, deer herds first increased rapidly, then declined as overbrowsing curtailed forage growth. Habitat was also affected by the development of the timber stand: as trees increased in size and density they excluded most of the understory, but forage became more plentiful after a timber harvest.

——— and GOODRUM, P. D.
1961. JAPANESE HONEYSUCKLE, LONICERA JAPONICA. Deer Browse Plants of Southern Forests, pp. 38-39, illus. U. S. Forest Serv. South. and Southeast. Forest Expt. Stas.
See Halls and Ripley, 1961.

——— and RIPLEY, T. H.
1958. THE FUTURE OF WILDLIFE IN THE SOUTHERN FOREST. Forest Farmer 18(3): 5, 14-16.
Describes current forest wildlife habitat research and suggests several lines of investigation.

* ——— and RIPLEY, T. H. (Editors)
1961. DEER BROWSE PLANTS OF SOUTHERN FORESTS. U. S. Forest Serv. South. and Southeast. Forest Expt. Stas., 78 pp., illus.
Illustrated guide to identification of about 35 species or species groups, with some information on forage value and management. Accounts of the individual species were prepared by authorities from all parts of the South.

RICH, R. W.
1959. AERIAL PHOTOGRAPHY AS A MEANS OF MEASURING PLANT COVER AND COMPOSITION. Techniques and Methods of Measuring Understory Vegetation, pp. 79-81. U. S. Forest Serv. South. and Southeast. Forest Expt. Stas.
Describes a method of classifying forest stands from small-scale panchromatic photographs and procedures for sampling vegetation within types delineated from photograph.

———
1961. YELLOW JESSAMINE, GELSEMIUM SEMPERVIRENS. Deer Browse Plants of Southern Forests, pp. 24-25, illus. U. S. Forest Serv. South. and Southeast. Forest Expt. Stas.
See Halls and Ripley, 1961.

STEARNS, F. W.
1959. FLORISTIC COMPOSITION AS MEASURED BY PLANT NUMBER, FREQUENCY OF OCCURRENCE, AND PLANT COVER. Techniques and Methods of Measuring Understory Vegetation, pp. 84-94, illus. U. S. Forest Serv. South. and Southeast. Forest Expt. Stas.
" . . . Recently developed indices extend the possibilities for application of floristic analysis to many management and research problems."

SITE

BEAUFAIT, W. R.
1955. SOIL PROFILE OBSERVATIONS RELATING TO DROUGHT DAMAGE IN BLACK WILLOW STANDS. Jour. Forestry 53: 517.
Black willows on deep clay soil survived a drought that killed willows on adjacent sites where the clay was only 32 inches deep and underlain by fine sand. The roots had penetrated the clay deeply, but had extended only a few inches into the usually saturated sand.

* ———
1956. INFLUENCE OF SOIL AND TOPOGRAPHY ON WILLOW OAK SITES. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 148, 12 pp., illus.
In the Mississippi Delta, growth of willow oak can be predicted from the topographic position of the stand and the percent of clay in the soil. In non-Delta river bottoms of the South the topographic position and amount of potassium can be used as indices.

* BROADFOOT, W. M.
1960. FIELD GUIDE FOR EVALUATING COTTONWOOD SITES. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 178, 6 pp.
Two methods applicable to the Midsouth. The first provides a fast field classification of sites from determinations of soil texture, internal drainage, and inherent moisture conditions. The second requires the soil to be identified by standard series and phase.

* ———
1961. GUIDE FOR EVALUATING CHERRYBARK OAK SITES. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 190, 9 pp., illus.
Three methods are described. The two most accurate require determinations of topsoil depth, internal drainage as indicated by depth to mottling, and presence or absence of a hardpan.

* ———
1961. SITE AFFECTS GRADE OF CHERRYBARK OAK. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 134.
Number of potential logs, vigor, and grade of butt log declined as site index fell below 95; insect attack increased.

* ———
1961. TOPSOIL MAKES SITE DIFFERENCE FOR CHERRYBARK OAK. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 132.
On loess ridges in the Midsouth, sites with more than 6 inches of topsoil are significantly better than those with less.

——— and KRINARD, R. M.
1959. GUIDE FOR EVALUATING SWEETGUM SITES. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 176, 8 pp., illus.
Three methods of estimating sweetgum sites in the Midsouth: from amounts of clay and exchangeable potassium in the 36- to 48-inch soil layer; from texture and drainage characteristics of the soil; and from tabulated averages for standard soil series and phases.

* ——— and KRINARD, R. M.
1961. GROWTH OF HARDWOOD PLANTATIONS ON BOTTOMS IN LOESS AREAS. U. S. Forest Serv. Tree Planters' Notes 48, pp. 3-8, illus. *Also in* Forest Farmer 21(5): 9-11, illus. 1962.
Pictorial description of 17- to 25-year-old plantations, chiefly of oaks and gums.

* ——— and MCKNIGHT, J. S.
1961. SOIL SUITABILITY FOR HARDWOODS IN MISSISSIPPI DELTA.

Miss. Farm Res. 24(6): 5. *Also as* Miss. Agr. Expt. Sta. Inform. Sheet 716, 2 pp.
Tabular summary.

* ———— and McKnight, J. S.
1961. SOIL SUITABILITY FOR FOREST TREES IN DEEP LOESS AREA. Miss. Farm Res. 24(9): 5. *Also as* Miss. Agr. Expt. Sta. Inform. Sheet 722, 2 pp.

* ———— and McKnight, J. S.
1961. SOIL SUITABILITY FOR FOREST TREES IN THIN LOESS AREA. Miss. Farm Res. 24(10): 8. *Also as* Miss. Agr. Expt. Sta. Inform. Sheet 729, 2 pp.

* Burton, J. D., and Gwinner, M. W.
1960. PLATEAU PINES WEATHER ORDEAL BY ICE. South. Lumberman 201(2513): 106-108, illus.
A severe ice storm struck the Cumberland Plateau in March 1960. Loblolly plantations recently thinned for pulpwood, and Virginia pine more than 25 years old, were hardest hit; but most trees recovered by the end of summer. In shortleaf pine only young stands were damaged, and white pine plantations were unaffected. Loblolly is not native to the region and its performance is encouraging.

Croker, T. C., Jr.
1958. SOIL DEPTH AFFECTS WINDFIRMNESS OF LONGLEAF PINE. Jour. Forestry 56: 432, illus.
Windthrow from a hurricane was worst on sites underlain by clay at a shallow depth.

* Nelson, T. C., and Beaufait, W. R.
1957. STUDIES IN SITE EVALUATION FOR SOUTHERN HARDWOODS. Soc. Amer. Foresters Proc. 1956: 67-70, illus.
An account of current studies by the Southeastern and Southern Forest Experiment Stations.

* Row, Clark.
1960. SOIL-SITE RELATIONS OF OLD-FIELD SLASH PINE PLANTATIONS IN CAROLINA SANDHILLS. Jour. Forestry 58: 704-707, illus.
Heights of slash plantations were estimated from their age and two soil variables: depth to a fine-textured horizon, and thickness of the A_1 horizon.

* Shoulders, Eugene.
1959. LOBLOLLY AND SLASH PINES MAKE GOOD GROWTH. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 124.
The two species appear to grow about equally well on moist, well-drained sites in Louisiana.

* Wakeley, P. C., and Marrero, José.
1958. FIVE-YEAR INTERCEPT AS SITE INDEX IN SOUTHERN PINE PLANTATIONS. Jour. Forestry 56: 332-336, illus.
The intercept was taken as the 5-year period during the first year of which the tree attained breast height, and was determined by counting the whorls of primary branches. The method is mainly for use with stands up to 20 years old. One of its advantages over the conventional total height-total age method of site evaluation is that age of the trees need not be known.

Williston, H. L.
1958. LOBLOLLY PREFERRED OVER SHORTLEAF. Miss. Farm Res. 21(8): 7, illus. *Also as* Miss. Agr. Expt. Sta. Inform. Sheet 600, 2 pp., illus.
See next entry.

* ————
1958. SHORTLEAF VERSUS LOBLOLLY PINE IN NORTH MISSISSIPPI. Jour. Forestry 56: 761.
At age 23, loblolly plantations have produced 13 cords more wood per acre than adjacent shortleaf plantations.

* ————
1959. GROWTH OF FOUR SOUTHERN PINES IN WEST TENNESSEE. Jour. Forestry 57: 661-662.
Though planted well beyond their natural range, longleaf, slash, and loblolly pine have outgrown the native shortleaf. After 29 growing seasons, volumes per acre are 43 cords for loblolly, 39 for longleaf, 36 for slash, and 28 for shortleaf.

* ————
1960. LOBLOLLY MOVES NORTH. Forest Farmer 19(9): 11, 18, illus.
Three plantations, all established before 1940, indicate that loblolly can do well in north Mississippi and western Tennessee.

Woods, F. W.
1957. FACTORS LIMITING ROOT PENETRATION IN DEEP SANDS OF THE SOUTHEASTERN COASTAL PLAIN. Ecol. 38: 357-359, illus.
Roots form a thick mat in the 0- to 3-inch zone, seemingly because (1) many summer rains do not penetrate deeper, (2) this zone is more fertile than deeper ones, (3) surface temperatures in winter are warm enough for some growth, (4) organic matter decomposes in this zone before it is transported to lower depths.

———— Copeland, O. L., Jr., and Ostrom, C. E.
1957. SOIL MANAGEMENT FOR FOREST TREES. *Soil.* U. S. Dept. Agr. Yearbook 1957: 710-715, illus.
While the management of forest soils is still in its infancy, problems of soil water deficiencies and surpluses, soilborne diseases, fertility requirements for trees, and soil structure and stabilization are receiving increasing attention.

* Zahner, Robert.
1957. FIELD PROCEDURES FOR SOIL-SITE CLASSIFICATION OF PINE LAND IN SOUTH ARKANSAS AND NORTH LOUISIANA. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 155, 17 pp., illus.
Factors affecting site quality, how to measure site factors and estimate site index, and suggestions for mapping tracts in terms of site quality.

* ————
1957. MAPPING SOILS FOR PINE SITE QUALITY IN SOUTH ARKANSAS AND NORTH LOUISIANA. Jour. Forestry 55: 430-433, illus.
Mappable soil characteristics include surface soil thickness or texture, subsoil texture, and slope. A sample site-quality map of an 800-acre tract was prepared at a cost of about 0.1 man-hour per acre.

————
1958. FOR GROWING PINES, HOW GOOD IS YOUR LAND? Forest Farmer 17(8): 6-7, illus.
Suggestions for recognizing soil and topographic features that influence pine growth in south Arkansas and north Louisiana.

————
1958. OUR CURRENT RESEARCH NEEDS: SOIL, WATER AND TREE RELATIONSHIP. Forest Farmer 18(2): 14-15, illus.
Applied soils studies that are most needed fall into three groups: present site evaluation, prospective site evolution, and site amendment. But effective applied research cannot be carried on indefinitely without a program of basic research into the relations between soils and tree development.

* ————
1958. SITE-QUALITY RELATIONSHIPS OF PINE FORESTS IN SOUTHERN ARKANSAS AND NORTHERN LOUISIANA. Forest Sci. 4: 162-176, illus.
Loblolly does best on well-drained small stream bottoms. Both loblolly and shortleaf thrive on the well-drained loess, upland terrace, and flatwoods soils. In all topographic positions, the best sites are those with moderately deep sandy loam surface soils and clay loam subsoils.

WATERSHED

* ANDREWS, L. A., and BROADFOOT, W. M.
1958. THE SAN DIMAS SOIL CORE SAMPLER. Soil Sci. 85: 297-301, illus.
This sampler was designed to take undisturbed cores in deep soils, for the calibration of fiberglas soil-moisture units. It is also suitable for determinations of bulk density and soil-moisture tension.

* BARRETT, J. P.
1961. SOIL TEXTURE AND SOIL MOISTURE VALUES CLOSELY RELATED. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 135.
Moisture equivalent and percent moisture at 15 atmospheres' tension are closely related to soil texture. Moisture equivalent and percent moisture at 1/3-atmosphere are highly correlated.

* BASSETT, J. R., and ANDREW, L. E.
1960. SOIL SERIES CAN BE GROUPED FOR SPECIAL USES. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 130.
On the basis of topographic position and clay content, soil series as depicted on county survey maps can be combined for site index classification, trafficability estimation, watershed management, or other purposes that do not require delineation of individual soil series. This is an inference from a study of four silt loams in Mississippi.

* BROADFOOT, W. M.
1960. SOIL CRACKS IN SHARKEY CLAY CATCH RAINWATER. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 126.
When dry, this soil can absorb 4 inches of quick-falling rain.

* ———— and BURKE, H. D.
1958. SOIL-MOISTURE CONSTANTS AND THEIR VARIATION. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 166, 27 pp., illus.
Values for the most commonly used constants, under specific soil and cover conditions.

* BRUCE, R. R., RANEY, W. A., BROADFOOT, W. M., and VANDERFORD, H. B.
1958. PHYSICAL, CHEMICAL, AND MINERALOGICAL CHARACTERISTICS OF IMPORTANT MISSISSIPPI SOILS. Miss. Agr. Expt. Sta. Tech. Bul. 45, 36 pp., illus.
Soils investigated were Alligator, Atwood, Bibb, Bladen, Cuthbert, Dundee, Ecru, Grenada, Houston, Lakeland, Lexington, Memphis, Norfolk, Noxapater, Providence, Ruston, Savannah, Sharkey, Tippah, and Vaiden.

* BURKE, H. D., and KRUMBACH, A. W., JR.
1959. NITROGEN PROBE FOR SOIL-MOISTURE SAMPLING. Jour. Geophys. Res. 64: 1039-1042, illus.
Liquid nitrogen was poured into hollow probes thrust into the soil. As the nitrogen boiled off, soil froze to the outside of the probes. The probes were withdrawn after 2 minutes and the adhering soil removed in lengths corresponding to the layers for which a sample was desired.

———— KRUMBACH, A. W., JR., and RUSH, E. S.
1960. LABORATORY TESTS OF LIQUID NITROGEN SOIL-MOISTURE SAMPLERS. U. S. Army Engin. Waterways Expt. Sta. Misc. Paper 4-371, 29 pp., illus.
Reasonably accurate samples were obtained from soils whose moisture contents ranged from about 5 percent to well above the liquid limit.

———— and TURNBULL, W. J.
1959. PREDICTION OF SOIL MOISTURE FROM SOIL AND WEATHER RECORDS. Symposium Hannoversch-Münden (Water and Woodlands) 1: 69-75, illus. Publication 48, Internatl. Assoc. Sci. Hydrol. Gentbrugge, Belgium.
See entry under Carlson and Horton, 1959.

* CAMPBELL, R. S., and RICH, R. W.
1961. ESTIMATING SOIL MOISTURE FOR FIELD STUDIES OF PLANT GROWTH. Jour. Range Mangt. 14: 130-134, illus.
The soil-moisture prediction method developed at the Vicksburg Research Center offers a means of using rainfall records to estimate moisture in the surface foot. That such estimates may be convenient when actual measures are lacking was demonstrated with data on forage grass weights in southern Mississippi.

* CARLSON, C. A.
1959. APPROXIMATION OF THE FIELD MAXIMUM SOIL MOISTURE CONTENT. Soil Sci. Soc. Amer. Proc. 23: 403-405.
Equations for approximating field maximum from various factors were evaluated by application to 533 sites throughout the U. S. The 0.06-atmosphere moisture tension was the only single factor correlated with field maximum. With simultaneous analysis, sand content and wetness index were also primary.

* ———— and HORTON, J. S.
1959. DEVELOPMENT AND TESTING OF SOME AVERAGE RELATIONS FOR PREDICTING SOIL MOISTURE. Forecasting Trafficability of Soils Report 5. U. S. Army Engin. Waterways Expt. Sta. Tech. Memo. 3-331, 210 pp., illus.
Prediction relations, derived from data on sites throughout the U. S., were tested on 651 sites, mostly ones for which detailed soil-moisture and strength data were unavailable. Accuracy was within reasonable limits for well-drained soils.

———— and PIERCE, R. S.
1955. THE FIELD MAXIMUM MOISTURE CONTENT. Soil Sci. Soc. Amer. Proc. 19: 81-83, illus.
The field maximum moisture content is defined as the naturally occurring wet limit of a soil or soil layer in its natural position. For most soils studied, it coincided with the 0.06-atmosphere soil-moisture tension value of core samples, but in poorly drained soils it approached the total pore volume.

* ———— REINHART, K. G., and HORTON, J. S.
1956. PREDICTING MOISTURE IN THE SURFACE FOOT OF SOIL. Soil Sci. Soc. Amer. Proc. 20: 412-415, illus.
In connection with trafficability studies being carried on by the Corps of Engineers, U. S. Army, the Vicksburg Infiltration Project determined the relationships that influence the wetting and drying of the surface foot of soil. It then devised a bookkeeping system for using these relations to make day-to-day predictions of soil moisture content.

* DOSS, B. D., and BROADFOOT, W. M.
1956. PROPERTIES OF 91 SOUTHERN SOIL SERIES. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 147, 16 pp., illus.
Tabular summaries.

FERGUSON, E. R., VOIGTEL, R. M., and SMITH, J. L.
1956. A PORTABLE POWER-DRIVEN SOIL SAMPLER. Soil Sci. 81: 419-421, illus.
A gasoline engine, carried on the operator's back, drives the soil auger through a flexible cable.

HORTON, J. S.
1955. USE OF ELECTRICAL SOIL-MOISTURE UNITS IN MOUNTAIN SOILS. Twenty-Third Ann. West. Snow Conf. Proc. 1955: 20-26, illus.
When to use electrical soil-moisture units, problems in calibrating them, and a new alignment chart for temperature correction.

KING, D. B.
1955. A TEST OF KRILIUM SOIL CONDITIONER IN GULLY PLANTING. Jour. Forestry 53: 731-732.
On hard-packed kaolinitic subsoils typical of gully bottoms in north Mississippi, the soil conditioner did not improve the survival or growth of planted loblolly pines.

* KRUMBACH, A. W., JR.
1959. EFFECTS OF MICRORELIEF ON DISTRIBUTION OF SOIL MOISTURE AND BULK DENSITY. Jour. Geophys. Res. 64: 1587-1590, illus.
Topography was mapped at contour intervals of 0.3 foot. Very small changes in elevation caused significant changes in moisture and bulk density for the 6- to 12-inch layer. The variation in moisture appeared greater when measurements were by volume than by weight.

* ———— and BASSETT, J. R.
1960. SAMPLE VARIATION IN A FALAYA SILT LOAM. U. S. Forest Serv. South. Forest Expt. Sta. South. Forest Res. 1: 11-12.
Data for determining the number of samples necessary for estimating, at various accuracies, the means of 8 physical properties.

* LULL, H. W., and REINHART, K. G.
1955. SOIL-MOISTURE MEASUREMENT. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 140, 56 pp., illus.
Reviews the various methods of measuring soil moisture and evaluates those used currently. Reports a study of variations in amount of soil moisture at several sites.

MCCLURKIN, D. C.
1956. ALUMINUM FOIL USEFUL AS A SOIL SAMPLE CONTAINER. Soil Sci. 82: 179.
Foil sold for kitchen use seals soil samples tightly, is unchanged by the temperatures of drying ovens, and is very light.

* ————
1961. ERODED SITES REBUILD SLOWLY. Miss. Farm Res. 24(3): 5.
Weeping lovegrass, switchgrass, and lespedeza survived and grew for 3 years on badly eroded sites in north Mississippi, but did not substantially improve soil qualities. Lovegrass was the most adaptable of the three.

* ————
1961. FERTILIZER NO HELP TO LOBLOLLY SEEDLINGS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 131.
Loblolly pine seedlings planted on eroded Brown Loam and Coastal Plain sites in north Mississippi did not respond to heavy fertilization.

* RUSH, E. S., and REINHART, K. G.
1955. FIELD TESTS OF NUCLEAR INSTRUMENTS FOR THE MEASUREMENT OF SOIL MOISTURE AND DENSITY. U. S. Army Engin. Waterways Expt. Sta. Misc. Paper 3-117, 26 pp., illus.
The instruments were of the type developed at Cornell University for the Civil Aeronautics Administration.

SMITH, J. L.
1959. SAMPLING FOREST FLOORS AND SOILS IN THE ARKANSAS HIGHLANDS. Techniques and Methods of Measuring Understory Vegetation, pp. 114-115. U. S. Forest Serv. South. and Southeast. Forest Expt. Stas.
In soils with much rock or erosion pavement the probability of sampling error increases, and extra precautions or modifications of standard techniques are necessary.

* ———— and LAWSON, E. R.
1959. SAMPLER FOR GRAVELLY PLASTIC SOILS. Soil Sci. 88: 56-57, illus.
The sampler consists of a straight cylinder, 2.0 inches in outside diameter, with walls 1/16 inch thick. The lower opening is constricted 0.003 to 0.005 inch to hold in the sample.

* STEARNS, F. W., and CARLSON, C. A.
1960. CORRELATIONS BETWEEN SOIL-MOISTURE DEPLETION, SOLAR RADIATION, AND OTHER ENVIRONMENTAL FACTORS. Jour. Geophys. Res. 65: 3727-3732, illus.
Measurements were made in an upland meadow on loessial soil near Vicksburg, Mississippi. Highest correlations of single factors with moisture loss were obtained with soil temperature and evaporation-pan data ($r = 0.79$ each), and with solar radiation ($r = 0.76$). Values for air temperature, vapor pressure deficit, humidity, and wind were progressively lower. Correlations with soil temperature or evaporation-pan data were somewhat improved by the addition of other factors in combination. Highest correlation was obtained with a site-derived depletion curve ($r = 0.85$) from the previous year.

STEPHENSON, G. K.
1957. HOLD THAT RAINDROP! South. Lumberman 195(2441): 162-164, illus.
About 57 percent of the South's watersheds are forested. The relation of forest cover to water is complex, and research is urgently needed. Of first priority for study are the shallow-soiled mountains of Arkansas and Oklahoma and the sand-clay deposits of the Coastal Plain.

STOECKELER, J. H., and THAMES, J. L.
1958. THE LAKE STATES PENETROMETER FOR MEASURING DEPTH OF SOIL FREEZING Soil Sci. 85: 47-50, illus.
The penetrometer consists of a steel rod, graduated in inches, sliding inside a lead-weighted driving hammer.

THAMES, J. L.
1958. HYDRAULIC INSERTER FOR SOIL-MOISTURE UNITS. Soil Sci. 86: 156-159, illus.
Construction plans for a hydraulic device to insert electrical soil-moisture units into the sidewalls of auger holes.

* ————
1959. MEASURING SOIL MOISTURE OVER LARGE AREAS WITH SINGLE INSTALLATIONS OF MOISTURE UNITS. Jour. Geophys. Res. 64: 257-262, illus.
It seems possible that with proper calibration, single installations of electrical soil-moisture units can be used to estimate moisture contents of outlying sites receiving similar amounts of rain but differing in vegetation and soils. In northern Wisconsin and west-central Mississippi, predicted moisture contents agreed closely with on-site measurements. Results were best at seasons when the soils remained near the wilting point or near field capacity.

* THAMES, J. L., and MCREYNOLDS, R. D.
1961. A HYDRAULIC SOIL SAMPLER. Agr. Engin. 42: 431-432, illus.
The sampler minimizes soil disturbance. It has been used in soils representing a wide range of bulk densities and textures.

———— and URSIC, S. J.
1957. IMPROVED RAIN GAGE SUPPORTS. Jour. Soil and Water Conserv. 12: 283, illus.
Designs for a concrete base for standard gages, and for a pipe-and-plank stand for recording gages.

———— and URSIC, S. J.
1960. RUNOFF AS A FUNCTION OF MOISTURE-STORAGE CAPACITY. Jour. Geophys. Res. 65: 651-654, illus.
On small watersheds in northern Mississippi surface runoff was strongly correlated with storage opportunity in the upper 6 inches of soil. A procedure for calculating antecedent soil-moisture storage over a watershed is presented.

TOBIASKI, R. A.
1959. SOIL-MOISTURE DEPLETION RATE IN PUERTO RICO LESS THAN IN DRIER CLIMATES. Jour. Forestry 57: 508-509.
See next entry.

———— BASSETT, J. R., and RUSH, E. S.
1960. TRAFFICABILITY PREDICTIONS IN TROPICAL SOILS; PUERTO RICO STUDY. U. S. Army Engin. Waterways Expt. Sta Misc. Paper 4-355, Rpt. 2, 110 pp., illus.
Soil-moisture predictions based on data collected at 8 sites were reasonably accurate when applied to 22 other sites in Puerto Rico. It was found that (a) Puerto Rico soils do not lose moisture as fast as U. S. soils, and the rate of loss seems to be unaffected by season; (b) the average rate of daily moisture depletion in the surface to 12-inch layer of Puerto Rico soils is about ½ the average summer rate and about equal to the spring-autumn rate in humid climates of the U. S.

———— and LARSON, D. E.
1955. THE DEVELOPMENT OF METHODS FOR PREDICTING SOIL MOISTURE CONTENT: REPORT ON THE FAIRBANKS, ALASKA, EXTENSION. U. S. Army Engin. Waterways Expt. Sta. Misc. Paper 4-135, 68+ pp., illus.
Relations were developed to allow predictions where only soil and vegetation information and a rain record are available.

* URSIC, S. J.
1961. POST-HOLE TREE PLANTING FOR STABILIZING GULLIES. Jour. Soil and Water Conserv. 16: 188-189, illus.
On badly eroded sites in northern Mississippi, holes 6 inches in diameter and 24 inches deep were made with a motorized digger, and filled with the best soil nearby. Loblolly seedlings planted on the fill survived and grew better than those on unprepared spots; spot mulching further improved survival and growth.

———— and THAMES, J. L.
1958. AN INEXPENSIVE RAIN GAGE. Jour. Soil and Water Conserv. 13: 231-232, illus.
Gages can be easily constructed from used No. 10 cans.

* ———— and THAMES, J. L.
1960. EFFECT OF COVER TYPES AND SOILS ON RUNOFF IN NORTHERN MISSISSIPPI. Jour. Geophys. Res. 65: 663-667, illus.
Surface runoff and peak flows were greatest from abandoned fields, intermediate from depleted upland hardwood forests, and least from 20-year-old loblolly pine plantations that had been established on eroding farm land. The pine cover has been a highly effective flood-abatement measure.

VICKSBURG RESEARCH CENTER, SOUTHERN FOREST EXPERIMENT STATION.
1957. INFORMATION FOR PREDICTING MOISTURE IN THE SURFACE FOOT OF VARIOUS SOILS. Forecasting Trafficability of Soils Report 4. U. S. Army Engin. Waterways Expt. Sta. Tech. Memo. 3-331, 102 pp., illus.
Summarizes site characteristics, soil properties, climate, and other information for soil-moisture predictions from the 131 sites used in developing the prediction method. Accuracy of the method was tested for every site by comparing predicted moisture to actual.

DISEASES

TREES

* BROADFOOT, W. M., and TOOLE, E. R.
1956. SOIL FACTORS MAY CAUSE GUM BLIGHT. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 106. *Also in* South. Lumberman 193(2417): 176.
Soil-moisture stress may be the main cause of sweetgum blight.

* ———— and TOOLE, E. R.
1957. DROUTH EFFECTS ON SOUTHERN HARDWOODS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 111.
See next entry.

* ———— and TOOLE, E. R.
1958. WHAT'S CAUSING THE MORTALITY IN SOUTHERN HARDWOODS? Jour. Soil and Water Conserv. 13: 276-277, illus.
The widespread dieback of hardwoods that was noted in the South during recent years was primarily caused by drouth.

* ———— and TOOLE, E. R.
1959. HARDWOODS RECOVERING FROM DROUGHT. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 119.
Ample rains in 1957 and 1958 halted losses of hardwoods from the record drought of 1952-1956.

* CZABATOR, F. J., and ENGHARDT, HANS.
1959. NURSERY-INFECTED SEEDLINGS DEVELOP FUSIFORM RUST CANKERS AFTER OUTPLANTING. U. S. Forest Serv. Tree Planters' Notes 37, pp. 23-25.
Many infections on southern pine nursery stock are still latent at lifting time, and hence cannot be detected during grading. The best assurance of rust-free planting stock is careful spraying with fungicides to prevent infection in the seedbed.

DAVIDSON, R. W., TOOLE, E R., and CAMPBELL, W. A.
1959. A PRELIMINARY NOTE ON THE CAUSE OF "PECKY" CYPRESS. U. S. Dept. Agr. Plant Dis. Rptr. 43: 806-808, illus.
A Stereum fungus appears to be the cause.

* Foster, A. A., and Henry, B. W.
1956. NURSERY CONTROL OF FUSIFORM RUST DEMANDS CAREFUL SPRAYING. U. S. Forest Serv. Tree Planters' Notes 24, pp. 13-15.
Properly done, spraying can usually keep the incidence of rust below one-half of one percent.

* Henry, B. W.
1955. BASAL BRANCHES NO SIGN OF RUST ON SLASH PINE SEEDLINGS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 100.
See next entry.

———
1956. BASAL BRANCHES NO SYMPTOM OF FUSIFORM RUST ON SLASH PINE SEEDLINGS. U. S. Forest Serv. Tree Planters' Notes 24, p. 16.
Branched seedlings need not be culled unless they also have globular or fusiform swellings on the stem.

Jewell, F. F.
1958. CRONARTIUM FUSIFORME EXTENT BELOW SLASH PINE BRANCH CANKERS. (Abstract.) Phytopath. 48: 394.
Mycelia could not be found more than ½ inch beyond the margins of cankers.

———
1960. INOCULATION OF SLASH PINE SEEDLINGS WITH CRONARTIUM FUSIFORME. Phytopath. 50: 48-51, illus.
Cotyledonary seedlings were inoculated by placing telia-bearing oak leaves over them and maintaining high humidity for 72 hours. One-year-old seedlings were inoculated by wrapping the new growth in telia-bearing oak leaves and maintaining high humidity, and also by inserting telia into new stem tissue.

* ———
1960. NEW PINE HOSTS FOR SOUTHERN FUSIFORM RUST. U. S. Dept. Agr. Plant Dis. Rptr. 44: 673.
C. fusiforme *galls were confirmed on the following previously unlisted pine hosts:* Pinus nigra *Arnold* P. cooperi *var.* ornelasi *Martinez,* P. pseudostrobus *Lindl., and* P. torreyana *Parry. Caribbean pine (correctly known as* P. caribaea *Morelet) and south Florida slash pine (*P. elliottii *var.* densa *Little & Dorman) were also confirmed as hosts of this rust; previous reports on* P. caribaea *probably referred to United States slash pine, now correctly known as* P. elliottii *Engelm. var.* elliottii.

* Koenigs, J. W.
1960. FOMES ANNOSUS: A BIBLIOGRAPHY WITH SUBJECT INDEX. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 181, 35 pp.
438 references.

Lightle, P. C.
1959. CONE RUST ON SLASH PINE CONTROLLED BY FERBAM. (Abstract.) Phytopath. 49: 318.
Sprays containing 2 pounds ferbam per 100 gallons of water were effective, especially if applied when the strobilus scales had opened or just after they had closed.

* ———
1960. BROWN-SPOT NEEDLE BLIGHT OF LONGLEAF PINE. U. S. Dept. Agr. Forest Pest Leaflet 44, 7 pp., illus.
Hosts, symptoms, and life history of Scirrhia acicola, *and control by spraying or prescribed burning.*

* ———
1960. FOMES ANNOSUS ROOT ROT OF LOBLOLLY PINE. U. S. Dept. Agr. Plant Dis. Rptr. 44: 423.
First known damage to loblolly was in a 21-year-old plantation in southern Mississippi during 1959. Later in the same year, the fungus was isolated from decayed roots of mature loblolly pines in a natural stand of central Alabama.

* ——— and Starr, J. W.
1957. HEARTROT IN SOUTHERN PINES. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 108.
Volume loss from heartrot of southern pines has been negligible in recent years, because the stands that replaced the virgin timber do not have much heartwood yet. As the second-growth attains greater ages, this situation is likely to change.

* Siggers, P. V.
1955. CONTROL OF THE FUSIFORM RUST OF SOUTHERN PINES. Jour. Forestry 53: 442-446, illus.
Life history, hosts, distribution, canker development, relation of infection to silvicultural practices and weather conditions, control in nursery and field.

Snow, G. A.
1958. CULTURAL DIFFERENCES IN ISOLATES OF SCIRRHIA ACICOLA FROM PINUS PALUSTRIS AND P. TAEDA. (Abstract.) Phytopath. 48: 398.
See second entry below.

* ———
1960. SPRAYING BEFORE RAINS IMPORTANT FOR FUSIFORM RUST CONTROL. U. S. Forest Serv. Tree Planters' Notes 43, pp. 17-18.
Slash pine nursery seedlings sprayed with ferbam 24, 48, or 72 hours before inoculation developed less rust than those sprayed 15 minutes after inoculation. Adding nickel chloride hexahydrate to the ferbam improved results.

* ———
1961. ARTIFICIAL INOCULATION OF LONGLEAF PINE WITH SCIRRHIA ACICOLA. Phytopath. 51: 186-188, illus.
Longleaf and loblolly seedlings were inoculated with isolates from loblolly as well as longleaf trees. Infection occurred only on immature longleaf needles, not on loblolly. Cultural characters varied widely from isolate to isolate, and could not be correlated with infectious characteristics. Isolates from longleaf were more infective than those from loblolly.

———
1961. SEMICARBAZONE OF CYCLOHEXIMIDE FOR CONTROLLING BROWN SPOT NEEDLE BLIGHT. (Abstract.) Phytopath. 51: 645.
Early results warrant further tests.

* Stover, W. S., and Toole, E. R.
1955. SWEETGUM BLIGHT IN LOUISIANA. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 99.
See next entry.

* ——— and Toole, E. R.
1955. SWEETGUM BLIGHT IN LOUISIANA AS DETERMINED BY THE FOREST SURVEY. U. S. Dept. Agr. Plant Dis. Rptr. 39: 864-866, illus.
Eight percent of Louisiana's sound cubic volume of sweetgum is in blighted trees.

* Toole, E. R.
1955. PERFORMANCE OF WILT-RESISTANT MIMOSA TREES IN HIGH-HAZARD AREAS. U. S. Dept. Agr. Plant Dis. Rptr. 39: 874.
Ten clones appear resistant.

* ———
1955. POLYPORUS HISPIDUS ON SOUTHERN BOTTOMLAND OAKS. Photopath. 45: 177-180, illus.
This fungus causes trunk cankers and decay. Associated heart rot exceeds the length of the canker by 2.38 ± 1 feet, and the length of cankers and rot increases 0.484 ± 0.02 foot yearly.

TOOLE, E. R.

1955. RED STAIN OF BOXELDER. U. S. Dept. Agr. Plant Dis. Rptr. 39: 66-67.
Fusarium negundi *Sherb. probably is the cause.*

* _____

1955. TWIG BLIGHT AND CANKER OF RED MULBERRY. U. S. Dept. Agr. Plant Dis. Rptr. 39: 657, illus.
Fusarium lateritium *(Nees) Snyder and Hansen appears to cause the blight, which so far has not been observed to kill trees.*

* _____

1956. HEARTROT IN BOTTOMLAND RED OAKS TWO YEARS AFTER INOCULATION. U. S. Dept. Agr. Plant Dis. Rptr. 40: 823-826, illus.
Polyporus hispidus, P. fissilis, *and* Fomes geotropus *have spread with equal rapidity.*

_____

1956. HISPIDUS CANKER Forest Farmer 16(1): 7, illus.
Willow and water oaks are especially susceptible to Polyporus hispidus. *The associated rot spreads so fast that cankered trees should be salvaged quickly.*

* _____

1957. CANKER DAMAGE TO HARDWOOD STUDIED IN DELTA. Miss. Farm Res. 20(5): 3, illus. *Also as* Miss. Agr. Expt. Sta. Inform. Sheet 563, 2 pp., illus.
Describes hispidus cankers, spiculosa cankers, and Irpex cankers. Recommends salvage of infected trees before heartrots destroy their value.

* _____

1957. FIRE SCARS ARE ENTRANCE FOR MOST HARDWOOD ROT. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 112.
More than three-fourths of the butt rot in commercial hardwood trees of the Mississippi Delta enters through fire wounds.

* _____

1957. TWIG CANKER OF SWEETGUM. U. S. Dept. Agr. Plant Dis. Rptr. 41: 808-809, illus.
Botryosphaeria ribis *Gross. and Dug. can cause cankers and kill twigs of sweetgum but appears to damage only shaded or weakened branches.*

* _____

1959. CANKER-ROTS IN SOUTHERN HARDWOODS. U. S. Dept. Agr. Forest Pest Leaflet 33, 4 pp., illus.
The chief rot fungi are those causing hispidus, spiculosa, and Irpex cankers.

* _____

1959. DECAY AFTER FIRE INJURY TO SOUTHERN BOTTOM-LAND HARDWOODS. U. S. Dept. Agr. Tech. Bul. 1189, 25 pp., illus.
Although more than 30 species of fungi were found behind fire scars, 5 caused half the decay cases identified. Within 4 years after a fire, the bark sloughs off most wounds and rot is well established. Except for the first 10 years after wounding, the average rate of spread of established rot per decade is 2.0 feet for overcup oak and sugarberry, 1.6 for water hickory, 1.3 for red oaks, 1.3 for green ash, and 0.9 foot for sweetgum and elm.

* _____

1959. SWEETGUM BLIGHT. U. S. Dept. Agr. Forest Pest Leaflet 37, 4 pp., illus.
History, symptoms, and cause.

* _____

1960. BUTT ROT OF SOUTHERN HARDWOODS. U. S. Dept. Agr. Forest Pest Leaflet 43, 4 pp., illus.
Most infections enter through wounds made by fire.

* _____

1960. DECAY 5 YEARS AFTER THINNING OF SWEETGUM SPROUT CLUMPS. U. S. Dept. Agr. Plant Dis. Rptr. 44: 784-788, illus.
The clumps were about 55 years old. They had originated near groundline, and the thinning caused no rot in those reserved for growth. Stumps decayed at a rate that was linearly related to their diameter and to the length to which they had split during logging.

* _____

1960. ROOT ROT OF WHITE OAK IN ARKANSAS. U. S. Dept. Agr. Plant Dis. Rptr. 44: 783, illus.
Corticium galactinum *(Fr.) Burt was found to be associated.*

* _____

1960. WHEN TO LOOK FOR HARDWOOD BLIGHT. Forests and People 10(1): 14-15, 48, illus.
In 1952-1956 an exceptionally severe drought damaged or killed many hardwoods in the Midsouth. Sweetgums were conspicuous victims, especially those on soils having a high portion of clay or a high concentration of soluble salts. While droughts of similar proportions may be rare, it appears that species other than sweetgum should be favored on the heavier slackwater soils and on most of the rolling uplands outside the Loessial Bluffs.

_____

1961. A NEW DISEASE OF SWAMP TUPELO. (Abstract.) Phytopath. 51: 646.
Fusarium solani *kills patches of cambium on the trunk; lesions heal and become overgrown, but they constitute lumber defects.*

* _____

1961. FIRE SCAR DEVELOPMENT. South. Lumberman 203 (2537): 111-112, illus.
Records kept for 7 years after a fire in a bottomland stand of oaks and hickories suggest ways of appraising damage from past fires or predicting mortality and decay from recent burns.

* _____

1961. NEW SYCAMORE CANKER. U. S. Dept. Agr. Plant Dis. Rptr. 45: 78.
Recent observations indicate a decline of a canker that in 1956 was killing tops of some large sycamores in the Mississippi Delta.

* _____

1961. ROT ENTRANCE THROUGH DEAD BRANCHES OF SOUTHERN HARDWOODS. Forest Sci. 7: 218-226, illus.
Rot was associated with 29 percent of the dead branches examined; 25 fungus species were identified, but half the rot was ascribable to 4 species. Rate of decay varied with fungus, branch diameter at time of death, age and diameter of scar at time of sampling, and tree species.

* _____ and BROADFOOT, W. M.

1959. IRRIGATION LESSENS SWEETGUM BLIGHT. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 120.
Well-stocked 40-year-old sweetgum stands were irrigated whenever available soil moisture fell below 40 percent of field maximum. The disease index dropped 68 percent, indicating marked recovery. On unwatered check plots, the disease index rose 26 percent.

_____ and BROADFOOT, W. M.

1959. SWEETGUM BLIGHT AS RELATED TO ALLUVIAL SOILS OF THE MISSISSIPPI RIVER FLOODPLAIN. Forest Sci. 5: 2-9, illus.

Significantly more blight was found on slackwater soils than on recent or old natural-levee soils. Blight increased as potassium in the 1- to 2-foot soil level increased, as sodium increased in the 2- to 3-foot level, as imbibitional water increased in the 0- to 2-foot level, and as bulk density decreased in the surface foot.

* ———— and FURNIVAL, G. M.
1957. PROGRESS OF HEART ROT FOLLOWING FIRE IN BOTTOMLAND RED OAKS. Jour. Forestry 55: 20-24, illus.
Height of heart rot in red oaks following wounding by fire can be predicted from length of hollow, height of butt bulge, or age and size of scar.

* ———— and HUCKENPAHLER, B. J.
1954. YELLOW-POPLAR DIEBACK. U. S. Dept. Agr. Plant Dis. Rptr. 38: 786-788, illus.
Symptoms and etiology of a disease believed to be caused by a species of Myxosporium on drought-weakened trees.

* ———— and LIGHTLE, P. C.
1960. STATUS OF PERSIMMON WILT, 1959. U. S. Dept. Agr. Plant Dis. Rptr. 44: 45, illus.
Wilt was reported from Oklahoma in 1959, has not recently been observed in Alabama, Arkansas, Louisiana, Mississippi, and Tennessee, even in areas where it was formerly common. All infections so far have been on sites where persimmon is a scrub or weed tree

* ———— and MORRIS, R. C.
1957. INSECT AND DISEASE PROBLEMS IN SOUTHERN HARDWOOD FORESTS. Soc. Amer. Foresters Proc. 1956: 65-67.
Much insect damage appears as defects that reduce the grade rather than the volume, and thus cause a value loss. Wood rendered cull by rot and disease is usually left in the forest or removed during primary manufacture. It represents a volume loss, but ordinarily does not degrade boards because it is not retained in the lumber.

* ———— and MORRIS, R. C.
1959. TRUNK LESION OF SWEETGUM. U. S. Dept. Agr. Plant Dis. Rptr. 43: 942-945, illus.
The lesions result from the killing of limited patches of cambium. They are common in bottom lands within about 100 miles of the Gulf Coast. Stands 10 to 20 years old tend to be most heavily infected, but occurrence in any area is patchy. The causal fungus is unidentified.

VERRALL, A. F.
1934. THE RESISTANCE OF SAPLINGS AND CERTAIN SEEDLINGS OF PINUS PALUSTRIS TO SEPTORIA ACICOLA. Phytopath. 24: 1262-1264.

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1936. THE DISSEMINATION OF SEPTORIA ACICOLA AND THE EFFECT OF GRASS FIRES ON IT IN PINE NEEDLES. Phytopath. 26: 1021-1024.

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1958. FUSIFORM RUST OF SOUTHERN PINES. U. S. Dept. Agr. Forest Pest Leaflet 26, 4 pp., illus.
Hosts, symptoms, life history, and control.

* ———
1958. PRUNING MAY CUT LOSS FROM RUST CANKERS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 115.
Suggestions for pruning slash and loblolly pines, so as to keep fusiform infections on branches from developing into stem cankers.

* ———
1961. SPREAD OF CRONARTIUM FUSIFORME BRANCH INFECTIONS. (Abstract.) Phytopath. 51: 646.
Proximal growth of individual galls varied greatly from year to year but averaged 2.4 ± 0.19 inches for loblolly pine and 1.8 ± 0.13 inches for slash pine. As most stem galls result from branch infections, removing branches that have galls 15 inches or less from the stem will help check damage.

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1961. THE USE OF FUNGICIDES IN SOUTHERN FORESTS. *In* The Use of Chemicals in Southern Forests. La. State Univ. Ninth Ann. Forestry Symposium Proc. 1960: 124-129.
For most diseases, economical fungicidal control in the forest is likely to require systemics, but spraying with bordeaux to control brown spot is feasible, ferbam can probably be used efficiently to check cone rust in seed orchards, and stump creosoting may sometimes be worth while to ward off Fomes annosus *root rot.*

* ————TOOLE, E. R., and LIGHTLE, P. C.
1959. OAK WILT IN OKLAHOMA AND ARKANSAS. U. S. Dept. Agr. Plant Dis. Rptr. 43: 1288.
Oak wilt was found for the first time in Oklahoma in 1959. The infection is a few miles west of the wilt area in Arkansas. In Arkansas, the wilt has not spread beyond the general range it occupied in 1951, but there has been a buildup in Sharp and Logan Counties.

PRODUCTS

* CAMPBELL, W. A., and VERRALL, A. F.
1956. FUNGUS ENEMIES OF HICKORY. U. S. Forest Serv. Southeast. Forest Expt. Sta. Hickory Task Force Rpt. 3, 8 pp., illus.
Leaf diseases, cankers, rots, and virus diseases all attack the living tree, but on the whole do not cause serious economic loss. Logs, bolts, and lumber will mould, stain, and decay unless protected by chemical treatment or prompt handling.

SMITH, V. K., JR.
1959. TREATING STORED WOOD: DECAY IN PULPWOOD INVENTORIES CAN BE REDUCED. Pulpwood Prod. 7(2): 10, 12, illus.
Green pine pulpwood bolts can be protected for 6 months by dipping them into a fungicide-insecticide combination. An effective formulation is 2 pounds of emulsifiable gamma BHC plus 10½ pounds of sodium pentachlorophenate in 50 gallons of water.

VERRALL, A. F.
1955. CONTROL OF SAPSTAIN ESSENTIAL IN PRODUCING BRIGHT, DRY LUMBER. South. Lumber Jour. 59(3): 27, 82, illus.
Chemical dips and proper seasoning are necessary to prevent sapstain and mould in newly sawn lumber and to head off decay.

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1955. NON-PRESSURE TREATMENTS FOR EXTERIOR WOODWORK OF BUILDINGS. Paper read at Vacuum Wood Preservers Institute, Biloxi, Miss., 4 pp.
See next entry.

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1955. PRESERVATIVE-MOISTURE REPELLENT TREATMENTS FOR WOODEN AMMUNITION PACKING BOXES—II. U. S. Army Ordnance Corps Rpt. R-1301, 56 pp., illus. Frankford Arsenal.
See Verrall, 1959, PRESERVATIVE MOISTURE-REPELLENT TREATMENTS FOR WOODEN PACKING BOXES.

VERRALL, A. F.
1956. NON-PRESSURE PRESERVATIVE TREATMENTS FOR EXTERIOR WOODWORK OF BUILDINGS. Forest Prod. Jour. 6(11): 17A-18A.
Brush, dip, and short soak treatments give protection in regions of moderate to heavy rainfall if buildings are designed properly.

* ———
1957. ABSORPTION AND PENETRATION OF PRESERVATIVES APPLIED TO SOUTHERN PINE WOOD BY DIPS OR SHORT-PERIOD SOAKS. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 157, 31 pp.
Dry wood treats better than moist and end penetration is about ten times lateral penetration. On-the-job preservative applications give only surface protection and must be supplemented by building design that minimizes moisture accumulation.

———
1957. HOW TO PREVENT FUNGUS DAMAGE TO WOOD STRUCTURES. Forest Prod. Jour. 7(1): 15A-17A.
To prevent decay, use well-manufactured lumber, and design structures so that water accumulation is minimized. Where decay hazard is high, choose decay-resistant or treated wood.

———
1957. PRESERVATIVE-WATER REPELLENT TREATMENTS FOR WOODEN PACKING BOXES—III. SUPPLEMENTARY TESTS. U. S. Army Ordnance Corps Rpt. R-1390, 23 pp., illus. Frankford Arsenal.
See Verrall, 1959, PRESERVATIVE MOISTURE-REPELLENT TREATMENTS FOR WOODEN PACKING BOXES.

* ———
1959. CONTROL OF WOOD DECAY IN BUILDINGS. Pest Control 27(10): 9, 11-13, 16, 18, 71-72, 74, illus.
General discussion.

* ———
1959. PRESERVATIVE MOISTURE-REPELLENT TREATMENTS FOR WOODEN PACKING BOXES. Forest Prod. Jour. 9: 1-22, illus.
After being treated with preservatives to which water-repelling formulations had been added, boxes were piled on the ground in Wisconsin, Mississippi, and the Panama Canal Zone. For temperate regions, a 3-minute dip gave satisfactory protection; for the tropics pressure treatment was desirable. Soil poisons were needed for protection against termites.

* ———
1960. CONDENSATION FROM AIR CONDITIONING. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 128.
Formation of a dewpoint within wooden walls or floors occasionally leads to floor buckling or structural decay. Prevention consists in lowering inside temperatures no more than is necessary, turning off the conditioner when it is not needed, and venting or using a soil cover in moist crawl spaces.

———
1960. PRESERVATIVE WATER-REPELLENT TREATMENTS FOR WIRE-BOUND VENEER BOXES. Appendix 2, Survey of suitability of present design of wire-bound boxes for M2A1 and M19A1 small arms ammunition boxes. Rpt. R-1564, pp. 15-27, illus. Frankford Arsenal.
Ten-second or longer dips in water-repellent preservatives protect wire-bound veneer boxes during outdoor storage. As rotary-cut veneers absorb excessive amounts of preservative, long-time drying may be necessary before the boxes can be used.

* ———
1960. PREVENTING MOISTURE PROBLEMS IN WOOD SIDING IN THE SOUTH. Forest Prod. Jour. 10: 148-151, illus.
Decay and paint problems can be minimized by planning for ample roof overhang, installing eaves gutters, using only wood free from incipient decay, putting breathing papers under siding and a water repellent-preservative on joints.

* ———
1960. PROLONGING LIFE OF WOOD SIDING. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 127.
See preceding entry.

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1960. THE DETERIORATION OF WOOD IN SERVICE. Utility Pole Conf. for Users, Treaters, and Prod. of Wood Poles Proc. 1960: 24-28.
Decay, subterranean termites, and marine borers cause the greatest damage.

* ———
1961. BRUSH, DIP, AND SOAK TREATMENTS WITH WATER-REPELLENT PRESERVATIVES. Forest Prod. Jour. 11: 23-26, illus.
Treatments are worth while if the buildings are designed so as to prevent frequent and severe wetting and to promote rapid drying.

INSECTS

TREES

* ALLEN, R. M., and COYNE, J. F.
1955. REDUCING LONGLEAF CONE LOSSES. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 98.
See next entry.

——— and COYNE, J. F.
1956. INSECT PROBLEMS IN FOREST-TREE GENETICS. Jour. Forestry 54: 193.
In southern Mississippi sprays of benzene hexachloride (BHC) have protected immature pine cones.

* BEAL, R. H.
1958. LIFE HABITS AND CONTROL OF PINE TIP MOTH: RESULTS FROM PRELIMINARY STUDIES. U. S. Forest Serv. South. Forest Expt. Sta. South. Forest Pest Rptr. 24, 5 pp., illus.
A laboratory study in southern Mississippi indicated that spraying within the week following peak emergence of the moths in spring should control adults, with perhaps a residual effect on larvae. A field test in Texas suggested that DDT may be satisfactory.

* ———
1960. PINE PITCH MOTH IN MISSISSIPPI. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 130.
Dioryctria clarioralis *(Walker), common in the southeastern Atlantic Coast States, has been found near Gulfport.*

BENNETT, W. H.
1956. IMPORTANT INSECT ENEMIES OF SOUTHERN PINES. U. S. Forest Serv. South. Forest Expt. Sta. South. Forest Pest Rptr. 10, 21 pp., illus.
Superseded by Bennett, Chellman, and Holt, 1958.

* ———

1956. PROTECTING SHADETREE PINES FROM BARK BEETLES. Arborist's News 21(7): 60-61, illus. *Also in* Forests and People 6(4): 40-41, illus. *Also in* Forest Farmer 16 (12): 7, 17-18, illus. 1957.
Three species of Ips *attack shadetree pines, but can be prevented by fertilizing and watering the trees to keep them healthy, and by spraying with BHC.*

———

1958. IPS CONTROL IN PULPWOOD OPERATIONS. The Unit, News Letter 74, p. 8.
Ips avulsus *is especially destructive to trees of pulpwood size, but it can be checked by keeping stands thrifty, salvaging trees that might become breeding places, and treating logging slash with BHC when insect hazard is great.*

* ———

1958. THE TEXAS LEAF-CUTTING ANT. U. S. Dept. Agr. Forest Pest Leaflet 23, 4 pp., illus.
The ants are serious pests of pine seedlings in east Texas and west-central Louisiana, but can be controlled by fumigating their colonies with methyl bromide.

* ———

1958. THIS IS ALICE FRONTALIS. U. S. Dept. Agr. Program Aid 294, 20 pp., illus
Illustrated booklet on southern pine beetle.

* ———

1958. WHAT YOU SHOULD KNOW ABOUT THE BLACK TURPENTINE BEETLE. Forest Farmer 18(3): 8, 16-18, illus.
In the Midsouth, more money is spent in controlling the black turpentine beetle than any other forest insect.

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1959. AERIAL INSECT SURVEYS IN EAST TEXAS. Tex. Forest News 38(3): 3, 8, illus.
How the Texas Forest Service, private landowners, and the Southern Forest Experiment Station conduct cooperative pest surveys.

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1959. FOREST INSECT CONDITIONS IN LOUISIANA. *In* Insect Conditions in Louisiana, 1958, pp. 18-20. Ent. Res. Dept. La. State Univ.
The black turpentine beetle was troublesome during 1958 and the Nantucket pine tip moth was unusually prevalent. The red-headed pine sawfly defoliated young plantations in central and southwestern parishes. The southern pine beetle was inactive, and ample rain curtailed damage from Ips.

———

1960. FOREST INSECT CONDITIONS IN LOUISIANA, 1959. *In* Insect Conditions in Louisiana, 1959, pp. 27-31. Ent. Res. Dept. La. State Univ.
The black turpentine beetle continued troublesome, but other bark beetles were less destructive than usual. The red-headed pine sawfly again defoliated plantations in central parishes, and insecticidal treatment became necessary in several plantations. In early May, spider mites caused noticeable browning of pine foliage over several million acres in the northern parishes, and the forest tent caterpillar defoliated thousands of acres of bottom-land hardwoods west of New Orleans.

* ———

1960. WHAT'S THE PITCH WITH THE BLACK TURPENTINE BEETLE? South. Lumberman 200(2490): 35-36, illus.
Prevention and control—a popularized account.

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1961. FOREST INSECT CONDITIONS IN LOUISIANA, 1960. *In* Insect Conditions in Louisiana, 1960, pp. 27-31. Ent. Res. Dept. La. State Univ.
Pine bark beetles were less destructive than in recent years but still killed more trees and required greater expenditures for control than all other forest insects. Defoliation of gums and other hardwoods by the forest tent caterpillar reduced growth and weakened stands over large areas. Woodborers caused lumber degrade by tunneling in living hardwoods.

———

1961. SOUTHERN STATES. *In* Forest Insect Conditions in the United States 1960, pp. 26-29, illus. U. S. Forest Serv.
Bark beetles and defoliators were the principal southern pests.

* ———CHELLMAN, C W., and HOLT, W. R.

1958. INSECT ENEMIES OF SOUTHERN PINES. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 164, 35 pp., illus.
Descriptions and drawings, and recommendations for control.

* ——— and OSTMARK, H. E.

1959. THE TRUTH ABOUT TESSIE TEREBRANS. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 174, 16 pp., illus.
Illustrated booklet on black turpentine beetle.

BONGBERG, J. W., and BENNETT, W. H.

1960. A STATUS REPORT ON FOREST INSECT CONDITIONS IN THE UNITED STATES IN 1959. FAO Plant Protect. Bul. 9(1): 1-10.
Bark beetles were the most destructive, but budworms, loopers, tussock moths, sawflies, spittlebugs, aphids, and others were damaging in many areas.

* BOYER, R. G.

1959. EVERGREEN BAGWORM. U. S. Forest Serv. South. Forest Expt. Sta. South. Forest Pest Rptr. 28, 2 pp., illus
The bagworm is troublesome chiefly on ornamentals where it may be controlled by spraying or by handpicking of individual insects.

CHELLMAN, C. W.

1958. MISCELLANEOUS INSECT ENEMIES OF SOUTHERN PINES. U. S. Forest Serv. South. Forest Expt. Sta. South. Forest Pest Rptr. 21, 14 pp., illus.
Superseded by Bennett, Chellman, and Holt, 1958.

COYNE, J. F.

1957. CONTROL OF CONE INSECTS IN SOUTHERN PINE. Fourth South. Forest Tree Impr. Conf. Proc. 1957: 64-66.
Natural control probably cannot be depended on.

* ———

1957. MIST BLOWER FOR SPRAYING SEED TREES. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 111.
The blower sprayed 70-foot pines with BHC to protect flowers and cones from insects.

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1959. NEODIPRION TAEDAE LINEARIS, A PEST OF LOBLOLLY AND SHORTLEAF PINES. U. S. Dept. Agr. Forest Pest Leaflet 34, 4 pp., illus.
In the south-central States this insect has caused huge losses by destroying the needles and thus retarding growth. DDT, applied from an airplane, controls it.

FERGUSON, E. R., and THATCHER, R. C.

1956. PALES AND HIS PALS. Forest Farmer 15(11): 10-11, 18, illus.
See next entry.

* FERGUSON, E. R., and THATCHER, R. C.
1956. PREPLANTING DIP FOR CONTROLLING PALES WEEVIL. Jour. Forestry 54: 469-470, illus.
Dipping tops of pine planting stock in a 0.2-percent water suspension of BHC reduces attack.

* HARRINGTON, T. A.
1955. TIP MOTH AND WEBWORM IN EAST TEXAS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 97.
Incidence of pine webworm was higher among loblolly seedlings in partial shade than in the open. Pine tip moth attack was not related to shading.

* HAY, C. J., and MORRIS, R. C.
1961. CARPENTERWORM. U. S. Dept. Agr. Forest Pest Leaflet 64, 8 pp., illus.
Larvae degrade hardwood timber by tunneling. No method is known for preventing attack in forest stands.

HELLER, R. C., COYNE, J. F., and BEAN, J. L.
1955. AIRPLANES INCREASE EFFECTIVENESS OF SOUTHERN PINE BEETLE SURVEYS. Jour. Forestry 53: 483-487, illus.
An aerial survey method developed in Texas was successfully used during the Mississippi beetle outbreak of 1952-53.

* HOLT, W. R.
1957. CONTROLLING THE TEXAS LEAF-CUTTING ANT. U. S. Forest Serv. South. Forest Expt. Sta. South. Forest Pest Rptr. 19, 4 pp., illus.
Details of control with methyl bromide.

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1961. METARRHIZIUM ANISOPLIAE (METCHNIKOFF) SOROKIN INFECTING LARVAE OF THE BLACK TURPENTINE BEETLE. Jour. Insect Path. 3:93.
The fungus had killed half the larval brood in a pine stump in southern Mississippi.

LEE, R. E., and COYNE, J. F.
1955. SUGGESTED GUIDES FOR DETECTING THE BLACK TURPENTINE BEETLE. Tex. Forest News 34(6): 4-5.
Where, how, and when to look for beetle infestations.

* ——— and SMITH, R. H.
1955. THE BLACK TURPENTINE BEETLE, ITS HABITS AND CONTROL. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 138, 14 pp., illus.
A review.

MORRIS, R. C.
1955. INSECT PROBLEMS IN SOUTHERN HARDWOOD FORESTS. South. Lumberman 191(2393): 136-139, illus.
Summarizes knowledge and indicates research needs.

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1956. COTTONWOOD LEAF BEETLE IN DELTA. Miss. Farm Res. 19(5): 3, illus. *Also as* Miss. Agr. Expt. Sta. Inform. Sheet 537, 2 pp., illus.
Larvae and adults of Chrysomela scripta *damage cottonwoods and willows in nurseries and young plantations but can be controlled with endrin or dieldrin sprays.*

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1956. INSECTS AND MISSISSIPPI HARDWOODS. Miss. Farm Res. 19(2): 4, 7, illus.
See second entry above.

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1957. HARDWOOD INSECT PROBLEMS IN THE DELTA. La. State Univ. Sixth Ann. Forestry Symposium Proc. 1957: 100-103.
Priority must be given to reducing damage from trunk borers in the living trees.

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1958. INSECT PESTS OF COTTONWOOD. Miss. Farm Res. 21(5): 8, illus. *Also as* Miss. Agr. Expt. Sta. Inform. Sheet 591, 2 pp., illus.
Describes cottonwood twig borer, cottonwood leaf beetle, blotch leaf miner, cottonwood root and stem borer, and the cottonwood borer.

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1958. TEST INSECTICIDES FOR TWIG BORER. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 118.
See second entry below.

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1959. INSECTS CAUSE DEGRADE IN OZARK OAKS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 120.
Potential values of lumber from Ozark red oaks were reduced as much as $19 per MBF by degrade caused when insects attacked the living trees.

* ———
1960. CONTROL OF COTTONWOOD INSECTS WITH A SYSTEMIC INSECTICIDE. Jour. Forestry 58: 718, illus.
Before they were planted, cottonwood cuttings were dipped in a dust containing 44 percent Thimet, which protected the trees for one year against the twig borer and other insects.

* MOSER, J. C.
1960. THE CASE OF THE INNOCENT ANTS. Forests and People 10(4): 30-33, illus.
Time and money intended for eradicating the destructive town ant are sometimes wasted on two relatively harmless species, Pogonomyrmex comanche *and* Trachymyrmex septentrionalis.

——— and BLUM, M. S.
1961. THE FORMICIDAE OF LOUISIANA. *In* Insect Conditions in Louisiana, 1960, pp. 48-50. Ent. Res. Dept. La. State Univ.
Six subfamilies, 43 genera, and 128 species occur in the State.

* NEELANDS, R. W.
1959. EXPOSING THE TOWN ANT. Forests and People 9(4): 18-19, 50, illus.
A colony of Atta texana *was exposed with bulldozers in an effort to determine its dimensions.*

*ORR, L. W., and KOWAL, R. J.
1956. PROGRESS IN FOREST ENTOMOLOGY IN THE SOUTH. Jour. Forestry 54: 653-656, illus.
Land managers are realizing that insects cause much mortality and growth loss even when there is no severe outbreak. State, Federal, and private action is being taken to prevent and control damage, but efforts are handicapped by lack of basic research on the biologies and habits of the insects.

*RUSSELL, T. E.
1958. CRICKET HAZARD. Forest Farmer 17(12): 12-13, 15, illus.
In central Louisiana the short-tailed cricket, Anurogryllus muticus *(DeG.) destroyed slash and longleaf pine seedlings. Damage was worst when other green vegetation was scarce.*

* ——— and MEANLEY, BROOKE.
1957. LISTEN FOR THE CRICKETS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 110.
See entry above.

* SHOULDERS, EUGENE.
1960. TOWN ANTS DAMAGE SLASH PINE PLANTATION. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 125.
Defoliation killed many newly planted pines.

* SMITH, R. H., and LEE, R. E.
1957. BLACK TURPENTINE BEETLE. U. S. Dept. Agr. Forest Pest Leaflet 12, 7 pp., illus.
Life history and habits, and control by natural means and with BHC.

* THATCHER, R. C.
1957. DAMAGE FROM PINE WEEVILS CAN BE AVOIDED. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 112.
See Thatcher, 1958 and 1960.

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1957. PINE REPRODUCTION WEEVILS: PRELIMINARY RESULTS FROM 1955-1957 STUDIES. U. S. Forest Serv. South. Forest Expt. Sta. South. Forest Pest Rptr. 18, 2 pp.
See Thatcher, 1958 and 1960.

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1957. PREVENTING PALES DAMAGE TO PINE REPRODUCTION. La. State Univ. Sixth Ann. Forestry Symposium Proc. 1957: 112-120.
See Thatcher, 1958 and 1960.

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1957. REFERENCES OF VALUE IN STUDIES OF INSECTS AFFECTING THE SOUTHERN PINES, AN ANNOTATED LIST. S. F. Austin State Col. Forestry Dept. Bul. 1, 37 pp.
Classified list.

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1958. PREPLANTING DIPS REDUCE WEEVIL DAMAGE TO PINE SEEDLINGS. Jour. Econ. Ent. 51: 915-916, illus.
Dipping the tops of loblolly pine planting stock in a BHC suspension or both the tops and roots in an emulsion of aldrin or heptachlor or in a suspension of dieldrin, all at concentrations of 1 percent, materially reduced seedling mortality in a Texas test. BHC damaged seedlings whose roots were dipped in it.

* _____
1959. BHC TOTAL DIPS TOXIC TO PINE SEEDLINGS. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 123.
See Thatcher, 1960, "TOXICITY OF BHC . . . ."

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1960. BARK BEETLES AFFECTING SOUTHERN PINES: A REVIEW OF CURRENT KNOWLEDGE. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 180, 25 pp.
Species characteristics, environmental influences on populations, predators and parasites, controls, research needs.

_____
1960. BUGS IN YOUR PINES? SUCH DAMAGE CAN BE EXPENSIVE. Tex. Forests and Texans 1(4): 3-4, illus.
Signs of attack, methods of control.

* _____
1960. INFLUENCE OF THE PITCH-EATING WEEVIL ON PINE REGENERATION IN EAST TEXAS. Forest Sci. 6: 354-361, illus.
Where overstory pines were cut within 3 months of the date pine seedlings were planted, weevil feeding resulted in heavy mortality of planted seedlings; natural seedlings of comparable size were also attacked Damage was much less on areas cut in July before being planted in January, and negligible on areas cut in April or earlier. Incidence of attack did not significantly vary with the pine species in the test—loblolly, shortleaf, and slash.

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1960. TOXICITY OF BHC TO LOBLOLLY PINE SEEDLINGS. Jour. Econ. Ent. 53: 175-176, illus.
Dipping both roots and tops of planting stock in 1 and 2 percent BHC suspensions reduced survival and growth for 2 years. Dipping only the tops avoided phytotoxic effects and still gave protection against pine reproduction weevils.

* WARREN, L. O., and COYNE, J. F.
1958. THE PINE SAWFLY, NEODIPRION TAEDAE LINEARIS ROSS, IN ARKANSAS. Ark. Agr. Expt. Sta. Bul. 602, 23 pp., illus.
Nomenclature, history of infestation, hosts, life history, and controls.

PRODUCTS

* BLEW, J. O., JR., and JOHNSTON, H. R.
1956. AN INTERNATIONAL TERMITE EXPOSURE TEST—TWENTY-SECOND PROGRESS REPORT. Amer. Wood-Preservers' Assoc., 10 pp.
Installations are in the Canal Zone, at Canberra, Australia, and in Transvaal, South Africa. An installation in Hawaii was closed in 1951.

* JOHNSTON, H. R.
1956. SOIL POISONS FOR SUBTERRANEAN TERMITES. U. S. Forest Serv. South. Forest Expt. Sta. Occas. Paper 152, 8 pp. *Revised in 1960 as* SOIL TREATMENTS FOR SUBTERRANEAN TERMITES. 6 pp. *Also as* SOIL POISONS FOR THE PREVENTION AND CONTROL OF SUBTERRANEAN TERMITES IN BUILDINGS. Tenth Int. Cong. Ent. Proc. 4: 423-432. 1958.
Chemicals and dosages for preventing or controlling infestations in buildings.

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1957. SOIL POISONS CAN THWART TERMITES. U. S. Forest Serv. South. Forest Expt. Sta. South. Forestry Notes 107.
See preceding entry.

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1958. TESTS WITH SOIL POISONS FOR CONTROLLING SUBTERRANEAN TERMITES. Pest Control 26(2): 9, 11-16, illus.
See second entry above.

_____ and OSMUN, J. V.
1960. GOOD-BY TERMITE CONTROL? Pest Control 28(5): 62-63, illus.
"There seems to be a tendency on the part of certain manufacturers, formulators, and pest control operators to gradually reduce, for various reasons, the amount of chemical recommended for soil treatment. This is a short-sighted policy that is certain to result in loss of public confidence when treatment failures become common."

+ _____ SMITH, R. H., and ST. GEORGE, R. A.
1955. PREVENTION AND CONTROL OF LYCTUS POWDER-POST BEETLES. South. Lumberman 190(2375): 72, 74, illus. *Also in* Pest Control 26(1): 39-42, illus. 1958.
Chemicals and dosages for protecting both green hardwood lumber and dry hardwood products.

MORRIS, R. C.
1957. LUMBER DEFECT—WHAT IS THE INSECT'S SHARE? South. Lumberman 195(2341): 26-27, illus.
Oak logs from Mississippi River bottoms were sawn and then graded twice—once with full cognizance of defects caused by insects, and once with such defects disregarded. At current market prices for the lumber, the defects reduced the value by $22 per M.

* ORR, L. W.
1959. PROTECTING FOREST PRODUCTS FROM INSECTS. Jour. Forestry 57: 639-640.
". . . Unless effective and practical measures for preventing deterioration of wood are developed and are accepted by industry and the American public, substitute materials are likely to be used for more and more of the purposes for which wood has been considered the best."

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1955.	*Issue 6, April 18,	5 pp.
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1958.	*Issue 20, Jan.17,	10 pp.
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OCCASIONAL PAPER NO. 110 OCTOBER 1947

BUILDING UP
A POORLY STOCKED FARM FOREST

By

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BUILDING UP A POORLY STOCKED FARM FOREST

By Hamlin L. Williston and Ike W. Rawls
Southern Forest Experiment Station

How much yearly income can a farmer in south Arkansas or northern Louisiana expect from his forest? In 1937 the Crossett Branch of the Southern Forest Experiment Station started a farm woodland study to find out. The foresters at this Branch thought that a well-stocked farm forest could produce a crop every year, just as a cotton field or potato patch does. The trouble was that most farm forests in the area were--and still are--badly understocked. That raised a second question: What is the best way of developing a good forest from a run-down stand?

Two areas were selected for study. One well-stocked 40-acre pine-hardwood forest (Compartment 51 of the Crossett Experimental Forest) was used to determine the possible returns from farm woodlands once the stands had been built up. Another area of 34 acres (Compartment 56) had a light stand of loblolly and shortleaf pine. The pines were of low quality, though, and a very large number of nearly worthless hardwoods were competing with them.

Both forests have now been under management for 10 years. The returns from the better tract have been reported annually by this Station. This paper describes the results on the "poor" forest.

What the Understocked Forest Was Like in 1937

The "poor" area had been heavily cut over prior to 1937 and, like so many farm woodlands in the area, had been burned by many uncontrolled fires. As a result, the number and quality of the pine trees had been quite seriously reduced, and low-grade hardwoods were monopolizing nearly 50 percent of the growing space. The merchantable stand per acre was about 1,895 board feet (Doyle rule) of pine and 117 board feet of hardwood sawlogs, 5.4 cords of pine pulpwood, and 2.6 cords of hardwood chemical wood and fuelwood. (Chemical wood is used in the production of charcoal, acetic acid, and methanol.)

Table 1 shows the number of merchantable trees present in 1937. The table does not include the large but worthless hardwoods nor show that the ground was covered with a dense growth of low-grade hardwoods below 5 inches in diameter at breast height.

Table 1.--Number of merchantable trees per acre

Species	1937 inventory	Cut 1939-46	1946 inventory
Pine			
Cordwood size 1/	68	15	67
Sawlog size 2/	19	8	20
Red and white oak			
Cordwood size 1/	38	50	4
Sawlog size 2/	2	2	0
Other salable hardwoods			
Cordwood size 1/	15	22	6
Sawlog size 2/	2	1	0
All trees			
Cordwood size 1/	121	87	77
Sawlog size 2/	23	11	20

1/ Pines 3.6 to 11.5 inches in diameter at breast height (d.b.h.), and/or hardwoods 4.6 to 11.5 inches d.b.h.
2/ Trees 11.6 inches and over, d.b.h.

Building Up the Forest

Stocking on this forest was thus quite low in 1937. Nevertheless, annual cuts were prescribed to see if the stand could not pay its way while being built up in productiveness. Such yearly harvests would place the stand in good growing condition at an early date. They would also give a cash income each year. Annual cuts would also permit prompt thinning of dense groups of trees and the removal of the large crop of small, low-grade hardwoods as soon as they became merchantable.

Although records were begun in 1937, the first cut was not made until 1939. The eighth cut was made in 1946. In these eight cuts, 15 of the original 68 cordwood-size pines per acre and 8 of the 19 pines per acre of sawlog size (11.6 inches d.b.h. or over) were cut and marketed. A few of these trees were mature, some were in groups that needed thinning, and others were too limby ever to produce good-quality saw timber. The 1946 inventory showed that many trees of cordwood size

in 1937 had grown into sawlog size during the 1937-46 period. Likewise, some trees below cordwood size in 1937 grew into this size by 1946. In fact, this growth in size has been great enough so that today the stand has as many pine trees of cordwood size and larger as it did in 1937, even though a good many were cut between 1937 and 1946. The size of the average saw-timber tree has also increased considerably.

When the study began, the stand contained 57 merchantable hardwoods per acre of cordwood size or larger. More than that number were cut by 1946. In addition, the large, unmerchantable hardwoods--about 1 per acre--were girdled at a cost of a few cents apiece.

Although the pine stand is still very light, it has grown, during the ten growing seasons since 1937, at the rate of 168 board feet per acre per year (Table 2). Furthermore, the volume of pine sawlogs present after the eighth cut was 3,022 board feet per acre--1,127 more than before the first cut was made. During these 10 years

Table 2.--Wood volume growth per acre

(Board-foot measurements are in Doyle rule)

Item	Pine		Red and white oak		Other salable hardwoods		All trees	
	Cordwood size 1/	Sawlog size 2/	Cordwood size 1/	Sawlog size 2/	Cordwood size 1/	Sawlog size 2/	Cordwood size 1/	Sawlog size 2/
	Cords	Bd.ft.	Cords	Bd.ft.	Cords	Bd.ft.	Cords	Bd.ft.
1937 inventory	5.43	1,895	2.11	63	0.52	54	8.06	2,012
Cut, 1939 to 1946	3.83	551	3.74	3/20	.92	3/17	8.49	588
1946 inventory	6.05	3,022	.19	0	.15	0	6.39	3,022
10-year growth	4.45	1,678	1.82	3/-43	.55	3/-37	6.82	1,598
Annual growth	.44	168	.18	-4	.06	-4	.68	160

1/ Pines 3.6 to 11.5 inches d.b.h., and/or hardwoods 4.6 to 11.5 inches d.b.h.
2/ Pines and hardwoods 11.6 inches or over, d.b.h.
3/ Besides those actually made into sawlogs, sawlog-size hardwoods were also cut into chemical wood. Hardwoods so used are listed as negative board-foot growth for the 10-year period.

the volume of the average pine saw-timber tree increased from about 100 board feet to about 150 board feet. The stand also contains 6 cords of pine pulpwood per acre and a very large number of young pine of near-pulpwood size.

Fire was kept completely out of the forest.

Today, as a result of the cutting practices and the protection from fire, an excellent stand of young pine covers nearly the whole 34 acres. (Much of the pine is still under 4 inches in diameter and hence does not show in Table 2.) The forest has been changed from a ragged growth of half pine and half hardwood to a well-stocked stand of nearly pure shortleaf and loblolly pine.

Money in the Pocket

Improvement cuts have thus made a good start toward building up the stand for good growth to come. How about the goal of providing annual income? Table 3 gives the answer. The eight cuts made during the 10-year period removed about 20,000 board feet of sawlogs, 130 cords of pulpwood, 105 cords of chemical wood, 53 cords of fuelwood, and 121 fence posts. On the stump, these products were worth $467. If the

Table 3.--Products harvested between 1937 and 1946

Item	Sawlogs	Pulp-wood	Fuel-wood	Chemical wood	Posts	Total
	Bd. ft. (Doyle)	Cords	Cords	Cords	No.	
Volume cut	19,982	130.27	53.40	105.02	121	...
Per acre	588	3.83	1.57	3.09	3.56	...
		Value (dollars) on stump				
Total cut	216.19	152.96	38.86	55.85	3.14	467.00
Per unit	10.82	1.17	.73	.53	.03	...
Per acre	6.36	4.50	1.14	1.64	.09	13.73
Per acre-year	.64	.45	.11	.16	.01	1.37
		Value (dollars) delivered at market				
Total cut	376.90	989.87	541.38	547.38	8.47	2,464.00
Per unit	18.86	7.60	10.14	5.21	.07	...
Per acre	11.09	29.11	15.92	16.10	.25	72.47
Per acre-year	1.11	2.91	1.59	1.61	.02	7.24

owner of the forest had been a farmer and had cut the products and delivered them to market, he would have received $2,464. Table 4 gives the cut of the various products for each year.

Table 4.--Volume of products cut

Year	Sawlogs	Pulpwood	Fuelwood	Chemical wood	Posts
	Bd. ft. (Doyle)	Cords	Cords	Cords	No.
1939	0	20.25	4.79	69.67	121
1940	2,996	10.22	0	3.40	0
1941	2,748	10.84	0	0	0
1942	5,314	4.45	9.77	0	0
1943	5,134	21.48	0	0	0
1944	0	60.00	0	31.95	0
1945	0	.36	38.84	0	0
1946	3,790	2.67	0	0	0
Total	19,982	130.27	53.40	105.02	121

Acre for acre, the stumpage return has been $1.37 per year for the 1937-46 period and the market value $7.24 per year. These returns would be more than enough to pay interest and taxes on the land and still leave a small profit.

Perhaps a better measure of the returns to date is the amount of profitable work the forest provided and the returns per hour of labor spent in making the different products. Table 5 shows that it took a total of 3,736 man-hours (467 8-hour man-days) to cut and deliver the sawlogs, pulpwood, chemical wood, fuelwood, and posts. For the eight cuts, this is an average of about 58 days of work per year for one man.

For this work (without allowing for what the timber would have sold for on the stump) an owner would have grossed about 66 cents per hour of labor. After deducting for taxes, fire protection, interest,[1] and for out-of-pocket expenses connected with harvesting, but not for stumpage value, he would have averaged 49 cents per hour of labor, net.

Table 5 shows that the returns per hour of labor were greatest for sawlogs and pulpwood, which are in general cut from the best trees, and lowest for chemical wood and fuelwood, the products of the low-quality trees. However, it is cutting out the low-quality, crowded, or diseased trees that gives the good trees room to grow and provides space for more pine seedlings to come in. The fact that undesirable or surplus trees could be sold for chemical wood and fuelwood added just that much more to the profits. As the forest fills up with good trees that can make high-priced products, the returns per man-hour will increase. In fact, the grade of the products improved so much

1/ Four percent interest on an assumed value (1937) of $15 per acre.

from cut to cut that the average net returns per hour for the last few years were considerably above 49 cents. Some of the increase, but not all of it, was due to higher prices.

Table 5.--Total volume and value (delivered at market) of wood cut

Product	Volume harvested	Value (delivered at market)	Labor of harvesting	Returns per man-hour 1/	
				Gross	Net
	Bd. ft. (Doyle)	Dollars	Man-hours	-- Dollars --	
Sawlogs	19,982	376.90	120.30	3.13	2.21
	Cords				
Pulpwood	130.27	989.87	1,315.72	.75	.57
Fuelwood	53.40	541.38	822.37	.66	.50
Chemical wood	105.02	547.38	1,453.48	.38	.28
	Number				
Posts	121	8.47	24.20	.35	.31
Total or average	...	2,464.00	3,736.07	2/.66	2/.49

1/ No allowance for stumpage. In computing net returns, however, deductions were made for taxes, fire protection, interest, and out-of-pocket expenses connected with harvesting.
2/ Weighted average.

Although many landowners do not have unlimited markets for chemical wood and fuelwood, the low-quality trees usually cut for these products need to be eliminated from the stands in order to make room for the more valuable pines to develop. In fact, even if such trees cannot be sold, it is still wise to chop them down or girdle or poison them. The increased growth of good pines will pay for the labor in a few years.

Conclusion

Property owners are often willing to make expensive improvements on their land or buildings because they hope to get their money back later on, in the form of increased income. The "poor" forest is being improved too, but at a profit, not a cost.

How much income will this forest produce when it is fully stocked? That question is being answered by the "good" Farm Forestry Forty at Crossett, which has been growing timber with an average market value of $14.82 per acre per year for the last 9 years. Returns per man-hour of labor for the 1946 harvest--with allowances for taxes, interest, and other expenses, but not for stumpage--were $1.34.

It will take some years to build up the poor stand enough to grow timber at that rate. But in the 10 years that the study has been under way the large numbers of cull and low-quality trees originally present have been eliminated and their places taken by high-value young pines. Over this period about 20,000 board feet of logs, 130 cords of pulpwood, 158 cords of fuelwood and chemical wood, and 121 fence posts have been removed. These products had a total market value of $2,464. This has been more than enough to pay all carrying costs and also to provide the owner with good wages for his work and a small profit besides. Even though a large volume of forest products has been removed, the stand now has 1,127 more board feet of sawlog-size pine and hundreds more young pine per acre than were present in 1937. From these trees increased returns can be expected in the near future.

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TABLES FOR ESTIMATING CUBIC-FOOT VOLUME OF TIMBER

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TABLES FOR ESTIMATING CUBIC-FOOT VOLUME OF TIMBER

By Clement Mesavage
Southern Forest Experiment Station

Purpose

The volume tables presented here have been compiled for use in estimating the cubic-foot contents of standing timber.[1] Although the tables were prepared primarily for eastern hardwoods and southern softwoods, they can be adapted to other species. The lower parts of the form class tables show not only volume in the sawlog portion of sawlog-size trees but also the scaling diameter of the top sawlog. The latter information is needed in obtaining estimates of volume in tops of conifers by use of Table 29 (attached to inside back cover). The top sections of the form class tables show volume in undersawlog-size trees of southern pines. All volumes are inside bark.

When these tables are used in conjunction with board-foot tables which have previously been published,[2] separate estimates of cubic- and

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1/ Because it has not been possible to get a wide check on the volumes shown for undersawlog-size trees and tops of sawlog-size conifers, these are subject to any changes which experience with the tables may indicate.

2/ Mesavage, Clement, and Girard, James W. Tables for estimating board-foot volume of timber. U. S. Forest Service. 94 pp. 1946.

board-foot volume for sawlog-size trees may be secured from the same cruise tally. Because both sets of tables were compiled from the same base, the volumes obtained are comparable. The two sets of tables also make it feasible to avoid overlapping of volumes when separate estimates are being obtained for board-foot volume in the sawlog portion and pulpwood volume in the tops.

Table Construction

Volume in the sawlog portion of trees

The lower sections of the form class tables show volume in the sawlog portion of trees as determined by tree diameter (o.b.) at breast height ($4\frac{1}{2}$ feet above the ground), number of 16-foot logs, and Girard form class. Butt-log volume for each tree was computed from Huber's formula, $A_{\frac{1}{2}} L$, where $A_{\frac{1}{2}}$ is the cross-sectional area, in square feet, inside bark at the middle of the butt log, and L is 16 feet, the length of the log. The middle diameter (i.b.) was derived in two steps:

(a) Diameter inside bark at the top of the first log was obtained by multiplying tree d.b.h. by the form class.

(b) To this figure was added an estimate of taper in the top 8 feet of the log. This taper varies with tree size. It also varies with the shape of the first log, which, for this purpose, is reflected by the form class. Table 1 shows the taper estimates used. They are based on measurements of southern pine butt logs.

Volume in the upper logs was computed from Smalian's formula $\frac{a + b}{2} L$, when a and b are cross-

sectional areas, in square feet, of the end diameters (i.b.) of each log, and L is 16 feet. The end diameters were obtained by subtracting, from the top diameter of the first log, estimates of taper in the upper logs. These tapers are shown in Table 2 of "Tables for estimating board-foot volume of timber." Volume for half-logs and for trees with odd-inch diameters was obtained by interpolation. Table 28 (pp. 66-67), showing cross-sectional areas of circles in square feet, has been included as a convenience.

Volume in the tops of sawlog-size southern pines

Cordwood volume above the sawlog portion of sawlog-size southern pines (Table 29) is based on length of merchantable cordwood top, form index of this top, and on the scaling diameter of the top sawlog. Length of top and top form index are estimated in the woods. The scaling diameter of the top sawlog is shown in the lower sections of the form class tables, along with the volume in the sawlog portion of sawlog-size trees. These scaling diameters were derived from the tapers shown in Table 2 of "Tables for estimating board-foot volume of timber." Volume in the tops was computed from Huber's formula. L is the length of merchantable cordwood top to a minimum diameter of 3 inches, inside bark. $A_{\frac{1}{2}}$ is computed for the middle diameter (i.b.) of the top. This diameter was derived from its relation to the scaling diameter of the last sawlog. In tops having a high form index, it is assumed that the middle d.i.b. averages 85 percent of the top sawlog scaling diameter, ranging from 80 percent to 90 percent; in tops with a medium form index, 75 percent, ranging from 70 to 79 percent; in tops with a low form index, 67 percent, ranging from 60 to 69 percent.

Volume in undersawlog-size trees

Volumes for undersawlog-size trees of each form class are shown in the upper sections of the form class tables. These volumes are based on tree d.o.b., merchantable length of cordwood stem (to a minimum top of 3 inches, i.b.), and form class.

The volumes were computed in two steps:

(a) Volume in the first 16 feet is from Huber's formula. The middle diameter (i.b.) was derived as for butt logs of sawlog-size trees.

(b) Volume in the merchantable stem above 16 feet is also from Huber's formula. The middle d.i.b. of this portion was derived from its relationship to d.i.b. at 16 feet. The percentage relationships on which these tables are based are:

Tree diameter o.b. (Inches)	Relationship between mid d.i.b. above 16 feet and d.i.b. at 16 feet (Percent)
6	90
8	85
10	80

Use of the Tables in Timber Estimating

General sampling procedures

These tables may be used in the same way as more conventional tables based only on diameter and height. Their recognition of tree form, however, results in two advantages which both simplify timber cruising and reduce its cost.

First, they may be applied directly, or adapted, to any species regardless of locality, thus saving the cost of constructing local volume tables. Secondly, they allow the use of sampling methods by which estimates, to any stipulated sampling accuracy, may be obtained at lowest cost.

Timber cruising usually involves a problem in sampling with the object of getting an acceptable estimate without spending the time and money which would be needed for complete measurement. The degree of accuracy needed depends greatly on the object of the survey; for purposes of illustration, it will be assumed that the needed standard error of estimate is 2½ percent. By definition, such an error means there is one chance in three that, due to sampling errors, the estimate will differ from the actual by more than 2½ percent, and about one chance in twenty that it will differ by more than 5 percent. This sampling error should not be confused with other types of errors, such as errors in measurements or calculations. Moreover, it will have no meaning unless the data are collected in a manner which will satisfy the requirements of sampling.

A number of arrangements can be designed for the collection of sample data. In timber cruising, however, variations of volume on an area are due to variations in tree number and

tree size. Because the cost of controlling these variations is not uniform, there is usually only one arrangement of data for any one set of circumstances which will yield an estimate to a stipulated sampling accuracy at a minimum cost. Recommendations for several general situations are as follows:

Cruises of small areas.--In cruises of areas smaller than 50 acres, a small sampling error can be secured at lowest cost by getting a 100 percent tree count by 2-inch diameter classes and obtaining an estimate of average volume per tree in each diameter class by sampling. This sampling consists of measuring the diameter, length, and form class of every "nth" tree tallied. The accuracy of the estimate will depend on the number of trees which are included in the sample. For a 2½ percent standard error, about 150 trees (all diameters combined) will suffice.

When detailed information on species and diameter classes is not needed, a complete tree count is cheapest for areas up to 500 acres if the trees are counted in broad diameter classes on a multiple hand tally register.3/ In this system4/ one man marks a line; two others walk parallel to this line about one chain apart and count all the trees on the strips which separate them, classifying the trees ocularly into broad diameter groups. An estimate of average volume per tree in each of these diameter groups is based

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3/ Rulison, D. E. A useful multiple tally register holder. Jour. Forestry 38(8):659-660. August 1940.

4/ Lockard, C. R. A rapid forestry control system. Northeastern Forest Experiment Station. 26 pp. 1942. [Mimeographed.]

on a sample, measurements of diameter, height, and form class being obtained on every "nth" tree. When 6-inch diameter groups are used, a $2\frac{1}{2}$ percent standard error will be obtained by sampling about 300 trees, all diameters combined.

When the permissible sampling error is large, a complete tree count is usually unnecessary. A sample of tree number will suffice.

Cruises of large areas.--For large areas, only the volume on sample plots is measured. A complete tree count is unnecessary. A few points about sample plots will clarify the use of these tables.

In sample plot cruising, relative cost of necessary operations must be kept in mind. On small areas, travel distance between samples is not time consuming and emphasis can be placed on obtaining a good sample of tree number. Estimates of height and form class may then be based on a fewer number of trees. For example, if the tree count is taken by diameter classes on a $\frac{1}{4}$-acre sample plot, height and form class may be taken of trees on a smaller plot, perhaps 1/40 acre in size. When travel distance between sample plots becomes great, however, it will be sampling economy to spend enough time on each sample to obtain careful measurements. Tree diameters should then be measured to the nearest inch, and the height of each tree should be carefully classified to the nearest half log. Form class of individual trees may also be recorded; when cruisers are not familiar with ocular form class estimating, an average form class may be based on measurements of at least 50 well-distributed

sample trees. These measurements may be secured by climbing or with the aid of a pole caliper.5/

Volume estimates for undersawlog-size trees may be obtained on a smaller-size sample plot than is needed for the larger trees, because there is ordinarily less variability in the stem count. On the Southern Forest Survey, the plot size for small trees is one-tenth as large as that used for the larger trees. Both plots, however, have the same center. There is similar opportunity to use such double sampling for obtaining data related to tree volume, such as cull allowance, tree or log grade distribution, and stem volume in the tops of sawlog-size trees. On the Southern Forest Survey, such data are based on sample plots which are one-twentieth as large as the plots used for estimates of gross volume.

Tree measurements needed

Form class.--Form class is the percentage ratio between the diameter, inside bark, at the top of the first log and the diameter, outside bark, at breast height. For example, a tree with a first log scaling diameter of 16.0 inches and a breast high diameter of 20.0 inches has a form class of (16.0 ÷ 20.0 x 100) 80 percent.

Relating form class to d.b.h. in swell-butted species such as cypress and tupelo, will result in a very low form class and cause the tables to underscale. To avoid this, tree diameter should be measured high enough on the tree to raise the form

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5/ Ferree, Miles J. The pole caliper. Jour. Forestry 44(8):594-595. August 1946.

class to at least 65 percent. Variations in form class, however, will be reduced if diameter is taken well above the pronounced swell.

When form class is estimated ocularly, cruisers should endeavor to classify it to the nearest 1 or 2 percent. In trees smaller than 10 inches, however, small changes in taper are hard to see; the following groups will suffice:

Form class group	Average form class
65-69	67
70-74	72
75-79	77
80-84	82
85-90	87

Length of sawlog portion.--Length of sawlog portion should be estimated in terms of 16-foot logs (plus trim allowance) to the nearest one-half log. The sawlog portion includes the stem from stump height to a point beyond which merchantability for saw timber is limited by cull or excessive taper. Evidences of excessive taper in the top log are: (1) log is above a fork;6/ (2) log has one limb with a base diameter equal to or exceeding one-half the diameter of the log; (3) log has several smaller limbs which collectively influence taper to the same extent as a single limb of the size specified in (2). To prevent an overestimate, top sawlogs which show such evidences

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6/ Estimates of volume in merchantable sawlogs or cordwood above a fork may be obtained by treating the section as an individual tree.

of excessive taper should not be included in the estimate of usable length even when they are merchantable.

In conifers, particularly the northern species, and in small hardwoods of species like ash, basswood, and poplar, top logs are frequently utilized to a small diameter because they are smooth and sound. Including these small top logs will also cause the tables to overscale. In trees with a d.b.h. of 10 inches, the sawlog portion should not include the stem above a point with a minimum diameter of less than 60 percent of d.b.h. This percentage relationship reduces progressively as tree diameter increases; for 40-inch trees, the top sawlog should be at least 40 percent of tree d.b.h. Normally, however, top logs in trees 16 inches and larger will be excluded because of excessive taper or cull before this minimum diameter is reached.

Cordwood length.—In undersawlog-size trees, cordwood length, in multiples of 4 feet, includes the stem above stump to the limit of cordwood merchantability, but not smaller than 3 inches, inside bark.

Length of tops in sawlog-size conifers.—In sawlog-size conifers, top length, also in multiples of 4 feet, includes the stem above the sawlog portion to the limit of cordwood merchantability, but not smaller than 3 inches, inside bark.

Top form index.—The top form index is the percentage ratio between the diameter inside bark at the mid-point of the usable top and the scaling diameter of the top sawlog. There is no practical way to measure it. It can only be classed ocularly

as high, medium, or low, the percentage ratios being 85, 75, and 67, respectively.

Table Corrections

When it seems likely that the average tapers assumed in these tables will result in excessive error, the volume in felled trees should be measured for comparison with the corresponding volumes in the tables. The comparison should preferably be summarized for each length class; measurement of about 50 trees of assorted diameters in each length class should be sufficient. The tables may thereafter be applied directly by adjusting tree form class; an average increase or decrease of 2 percent in cubic volume results from a change of 1 percent in form class.

Note: The Appendix contains instructions for converting cubic volume inside bark, as obtained from these tables, to cubic volume outside bark and to rough cords.

Table 1.—Taper in Top 8' of First 16' Log - Southern Pine

D.B.H.	Form Class					
	65	66	67	68	69	70
Inches	Taper in Inches					
6	.5	.5	.5	.4	.4	.4
8	.6	.5	.5	.5	.5	.5
10	.7	.7	.6	.6	.6	.6
12	.8	.8	.8	.7	.7	.7
14	.9	.9	.9	.8	.8	.8
16	1.1	1.0	1.0	1.0	.9	.9
18	1.3	1.2	1.2	1.2	1.1	1.1
20	1.5	1.5	1.4	1.4	1.3	1.3
22	1.8	1.7	1.7	1.6	1.5	1.5
24	2.1	2.0	2.0	1.9	1.8	1.8
26	2.5	2.4	2.4	2.3	2.2	2.1
28	3.0	2.9	2.8	2.7	2.6	2.5
30	3.5	3.4	3.3	3.2	3.0	2.9
32	4.2	4.0	3.9	3.7	3.5	3.4
34	4.9	4.6	4.5	4.2	4.1	3.9
36	5.5	5.2	5.0	4.8	4.6	4.3
38	6.0	5.7	5.5	5.2	5.0	4.7
40	6.4	6.0	5.8	5.5	5.3	5.0

D.B.H.	Form Class					
	78	79	80	81	82	83
Inches	Taper in Inches					
6	.4	.4	.4	.4	.3	.3
8	.4	.4	.4	.4	.4	.4
10	.5	.5	.5	.5	.5	.4
12	.6	.6	.5	.5	.5	.5
14	.7	.7	.6	.6	.6	.6
16	.8	.8	.7	.7	.7	.7
18	.9	.9	.8	.8	.8	.8
20	1.0	1.0	1.0	1.0	.9	.9
22	1.2	1.2	1.2	1.2	1.0	1.0
24	1.4	1.4	1.4	1.3	1.2	1.2
26	1.6	1.6	1.6	1.5	1.4	1.3
28	1.8	1.8	1.8	1.7	1.6	1.5
30	2.1	2.0	2.0	1.9	1.8	1.7
32	2.4	2.2	2.2	2.1	2.0	1.9
34	2.7	2.5	2.4	2.3	2.2	2.1
36	3.0	2.8	2.7	2.5	2.4	2.3
38	3.3	3.1	2.9	2.8	2.6	2.5
40	3.5	3.3	3.1	3.0	2.8	2.7

Table 1.—Continued

D.B.H.	Form Class						
	71	72	73	74	75	76	77
Inches	Taper in Inches						
6	.4	.4	.4	.4	.4	.4	.4
8	.5	.5	.5	.5	.5	.4	.4
10	.6	.6	.6	.5	.5	.5	.5
12	.7	.7	.7	.6	.6	.6	.6
14	.8	.8	.8	.7	.7	.7	.7
16	.9	.9	.9	.8	.8	.8	.8
18	1.1	1.0	1.0	1.0	.9	.9	.9
20	1.3	1.2	1.2	1.2	1.1	1.1	1.0
22	1.5	1.4	1.4	1.4	1.3	1.3	1.2
24	1.7	1.7	1.6	1.6	1.5	1.5	1.4
26	2.0	2.0	1.9	1.8	1.7	1.7	1.6
28	2.4	2.3	2.2	2.1	2.0	2.0	1.9
30	2.8	2.7	2.6	2.4	2.3	2.3	2.2
32	3.2	3.1	3.0	2.8	2.7	2.6	2.5
34	3.7	3.5	3.4	3.2	3.1	2.9	2.8
36	4.1	3.9	3.8	3.6	3.4	3.2	3.1
38	4.5	4.3	4.1	3.9	3.7	3.5	3.4
40	4.8	4.6	4.4	4.2	4.0	3.8	3.6

D.B.H.	Form Class						
	84	85	86	87	88	89	90
Inches	Taper in Inches						
6	.3	.3	.3	.3	.3	.3	.3
8	.4	.4	.4	.4	.3	.3	.3
10	.4	.4	.4	.4	.4	.4	.4
12	.5	.5	.5	.5	.4	.4	.4
14	.6	.6	.5	.5	.5	.5	.5
16	.7	.6	.6	.6	.6	.6	.5
18	.8	.7	.7	.7	.7	.7	.6
20	.9	.8	.8	.8	.8	.8	.7
22	1.0	1.0	1.0	1.0	.9	.9	.9
24	1.2	1.2	1.1	1.1	1.0	1.0	1.0
26	1.3	1.3	1.2	1.2	1.1	1.1	1.1
28	1.5	1.4	1.3	1.3	1.2	1.2	1.2
30	1.6	1.6	1.5	1.4	1.4	1.3	1.3
32	1.8	1.7	1.7	1.6	1.5	1.4	1.4
34	2.0	1.9	1.8	1.7	1.6	1.6	1.5
36	2.2	2.1	2.0	1.9	1.8	1.7	1.6
38	2.4	2.3	2.1	2.0	1.9	1.8	1.8
40	2.6	2.5	2.3	2.2	2.1	2.0	2.0

Table 2.--Gross volume (cubic feet, inside bark)
Form Class 65 Trees

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem					
	12	16	20	24	28	32
5	1.0	1.3	1.5	1.7	1.9	2.1
6	1.4	1.8	2.1	2.3	2.6	2.9
7	1.9	2.4	2.7	3.1	3.4	3.8
8	2.4	3.0	3.4	3.8	4.3	4.7
9	2.9	3.7	4.2	4.7	5.2	5.7
10	3.6	4.5	5.1	5.7	6.3	6.9

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs				
	1	1½	2	2½	3
10	4.5 - 6"	6.0 - 6"	7.5 - 5"		
11	5.4 - 7	7.2 - 6	9.1 - 6		
12	6.4 - 8	8.6 - 7	10.7 - 6	12.2 - 6"	13.8 - 5"
13	7.6 - 8	10.2 - 8	12.7 - 7	14.6 - 6	16.4 - 6
14	8.7 - 9	11.7 - 8	14.7 - 7	16.9 - 7	19.1 - 6
15	10.1 - 10	13.6 - 9	17.0 - 8	19.6 - 7	22.2 - 7
16	11.5 - 10	15.4 - 9	19.4 - 8	22.4 - 8	25.4 - 7
17	13.2 - 11	17.7 - 10	22.2 - 9	25.6 - 8	29.0 - 8
18	14.8 - 12	19.8 - 11	24.9 - 10	28.8 - 9	32.7 - 8
19	16.6 - 12	22.3 - 11	28.0 - 10	32.4 - 10	36.8 - 9
20	18.4 - 13	24.7 - 12	31.0 - 11	35.9 - 10	40.8 - 9
21	20.5 - 14	27.4 - 13	34.4 - 11	39.9 - 11	45.4 - 10
22	22.6 - 14	30.2 - 13	37.9 - 12	44.0 - 11	50.0 - 10
23	25.0 - 15	33.4 - 14	41.8 - 13	48.5 - 12	55.2 - 11
24	27.3 - 16	36.4 - 14	45.6 - 13	53.0 - 12	60.4 - 12
25	30.0 - 16	40.0 - 15	50.0 - 14	58.1 - 13	66.2 - 12
26	32.8 - 17	43.6 - 16	54.4 - 14	63.2 - 14	71.9 - 13
27	36.0 - 18	47.7 - 16	59.4 - 15	69.0 - 14	78.6 - 13
28	39.2 - 18	51.8 - 17	64.4 - 16	74.8 - 15	85.2 - 14
29	42.7 - 19	56.2 - 18	69.8 - 16	81.0 - 15	92.2 - 14
30	46.2 - 19	60.8 - 18	75.3 - 17	87.2 - 16	99.2 - 15
31	50.4 - 20	66.0 - 19	81.5 - 17	94.4 - 16	107.4 - 15
32	54.5 - 21	71.1 - 19	87.7 - 18	101.6 - 17	115.5 - 16
33	59.0 - 21	76.7 - 20	94.4 - 19	109.3 - 18	124.2 - 17
34	63.6 - 22	82.4 - 21	101.2 - 19	117.0 - 18	132.9 - 17
35	68.2 - 23	88.2 - 21	108.2 - 20	125.2 - 19	142.1 - 18
36	72.9 - 23	94.1 - 22	115.3 - 21	133.3 - 20	151.3 - 18
37	77.6 - 24	100.0 - 23	122.4 - 21	141.6 - 20	160.9 - 19
38	82.2 - 25	105.9 - 23	129.6 - 22	150.0 - 21	170.5 - 20
39	86.9 - 25	112.0 - 24	137.0 - 22	158.6 - 21	180.2 - 20
40	91.6 - 26	118.0 - 25	144.4 - 23	167.1 - 22	189.8 - 21

Table 2.--Continued

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem						
	36	40	44	48	52	56	60
5	2.3	2.5	2.7	2.9	3.1	3.3	3.5
6	3.1	3.4	3.7	3.9	4.2	4.5	4.7
7	4.1	4.5	4.8	5.2	5.5	5.9	6.2
8	5.1	5.5	6.0	6.4	6.8	7.2	7.7
9	6.2	6.7	7.2	7.7	8.2	8.7	9.2
10	7.4	8.0	8.6	9.2	9.8	10.4	11.0

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs					
	3½	4	4½	5	5½	6
10						
11						
12						
13						
14						
15						
16	27.7 - 6"	30.0 - 5"				
17	31.7 - 7	34.4 - 6				
18	35.7 - 7	38.7 - 6				
19	40.2 - 8	43.5 - 7				
20	44.6 - 8	48.3 - 7	51.3 - 6"	54.3 - 5"		
21	49.6 - 9	53.9 - 8	57.4 - 7	60.8 - 6		
22	54.8 - 9	59.5 - 8	63.4 - 7	67.4 - 6		
23	60.3 - 10	65.4 - 9	70.0 - 8	74.6 - 7		
24	65.9 - 10	71.4 - 9	76.6 - 8	81.9 - 7		
25	72.4 - 11	78.6 - 10	84.3 - 9	90.0 - 8		
26	78.8 - 12	85.7 - 10	92.0 - 9	98.2 - 8		
27	86.0 - 12	93.4 - 11	100.3 - 10	107.2 - 9		
28	93.1 - 13	101.0 - 11	108.6 - 10	116.1 - 9	123.0 - 8"	129.9 - 6"
29	100.7 - 13	109.2 - 12	117.6 - 11	126.0 - 10	133.8 - 8	141.7 - 7
30	108.4 - 14	117.5 - 12	126.6 - 11	135.8 - 10	144.6 - 9	153.5 - 7
31	117.4 - 14	127.4 - 13	137.0 - 12	146.6 - 10	156.3 - 9	166.0 - 8
32	126.4 - 15	137.2 - 13	147.3 - 12	157.4 - 11	168.0 - 10	178.5 - 8
33	135.8 - 15	147.4 - 14	158.3 - 13	169.2 - 11	180.7 - 10	192.2 - 9
34	145.3 - 16	157.7 - 14	169.3 - 13	180.9 - 12	193.4 - 11	205.9 - 9
35	155.4 - 16	168.6 - 15	181.1 - 14	193.6 - 12	206.6 - 11	219.6 - 10
36	165.4 - 17	179.6 - 16	193.0 - 14	206.3 - 13	219.8 - 12	233.3 - 10
37	175.8 - 18	190.8 - 16	205.3 - 15	219.8 - 14	234.0 - 12	248.3 - 11
38	186.3 - 18	202.1 - 17	217.6 - 15	233.2 - 14	248.2 - 13	263.3 - 11
39	197.1 - 19	214.0 - 17	230.1 - 16	246.2 - 15	262.2 - 13	278.2 - 12
40	207.8 - 19	225.9 - 18	242.5 - 17	259.1 - 15	276.1 - 14	293.1 - 12

Table 3.--Gross volume (cubic feet, inside bark)
Form Class 66 Trees

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem					
	12	16	20	24	28	32
5	1.1	1.3	1.5	1.7	2.0	2.2
6	1.5	1.8	2.1	2.4	2.7	2.9
7	1.9	2.4	2.7	3.1	3.4	3.8
8	2.4	3.0	3.4	3.9	4.3	4.8
9	3.0	3.8	4.3	4.8	5.4	5.9
10	3.7	4.7	5.3	5.9	6.5	7.1

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs				
	1	1½	2	2½	3
10	4.7 - 7"	6.2 - 6"	7.8 - 5"		
11	5.6 - 7	7.5 - 6	9.4 - 6		
12	6.6 - 8	8.8 - 7	11.0 - 6	12.6 - 6"	14.3 - 5"
13	7.8 - 9	10.4 - 8	13.0 - 7	15.0 - 6	17.0 - 6
14	8.9 - 9	12.0 - 8	15.1 - 7	17.4 - 7	19.6 - 6
15	10.3 - 10	13.9 - 9	17.5 - 8	20.2 - 7	22.9 - 7
16	11.7 - 11	15.8 - 10	19.9 - 9	23.0 - 8	26.2 - 7
17	13.4 - 11	18.0 - 10	22.7 - 9	26.3 - 9	29.9 - 8
18	15.0 - 12	20.2 - 11	25.5 - 10	29.6 - 9	33.6 - 8
19	17.0 - 13	22.8 - 12	28.7 - 10	33.2 - 10	37.8 - 9
20	18.9 - 13	25.4 - 12	31.9 - 11	37.0 - 10	42.1 - 10
21	20.9 - 14	28.1 - 13	35.3 - 12	41.0 - 11	46.6 - 10
22	22.9 - 14	30.8 - 13	38.7 - 12	44.9 - 11	51.1 - 11
23	25.2 - 15	33.9 - 14	42.6 - 13	49.5 - 12	56.4 - 11
24	27.6 - 16	37.0 - 15	46.4 - 13	54.0 - 13	61.7 - 12
25	30.6 - 16	40.9 - 15	51.2 - 14	59.6 - 13	68.0 - 12
26	33.5 - 17	44.8 - 16	56.0 - 15	65.1 - 14	74.2 - 13
27	36.8 - 18	48.9 - 17	61.0 - 15	71.0 - 14	81.0 - 14
28	40.0 - 18	53.0 - 17	66.1 - 16	76.9 - 15	87.7 - 14
29	43.5 - 19	57.6 - 18	71.6 - 17	83.2 - 16	94.8 - 15
30	47.0 - 20	62.0 - 18	77.0 - 17	89.4 - 16	101.8 - 15
31	51.0 - 20	67.0 - 19	83.1 - 18	96.5 - 17	109.9 - 16
32	55.0 - 21	72.1 - 20	89.2 - 18	103.6 - 17	118.0 - 16
33	59.3 - 22	77.6 - 20	95.8 - 19	111.2 - 18	126.5 - 17
34	63.6 - 22	83.0 - 21	102.3 - 20	118.6 - 19	135.0 - 18
35	68.5 - 23	89.2 - 22	109.8 - 20	127.4 - 19	144.9 - 18
36	73.4 - 24	95.4 - 22	117.4 - 21	136.1 - 20	154.8 - 19
37	78.1 - 24	101.4 - 23	124.6 - 22	144.6 - 21	164.6 - 20
38	82.8 - 25	107.3 - 24	131.8 - 22	153.0 - 21	174.3 - 20
39	87.2 - 26	113.1 - 24	139.0 - 23	161.4 - 22	183.7 - 21
40	91.6 - 26	118.8 - 25	146.1 - 23	169.6 - 22	193.1 - 21

Table 3.--Continued

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem						
	36	40	44	48	52	56	60
5	2.4	2.6	2.9	3.1	3.3	3.5	3.8
6	3.2	3.5	3.8	4.1	4.4	4.6	4.9
7	4.1	4.5	4.8	5.2	5.5	5.9	6.2
8	5.2	5.6	6.1	6.5	7.0	7.4	7.8
9	6.4	6.9	7.5	8.0	8.5	9.0	9.6
10	7.8	8.4	9.0	9.6	10.2	10.8	11.4

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs					
	3½	4	4½	5	5½	6
10						
11						
12						
13						
14						
15						
16	28.6 - 7"	31.0 - 6"				
17	32.6 - 7	35.4 - 6				
18	36.8 - 8	39.9 - 7				
19	41.4 - 8	44.9 - 7				
20	46.0 - 9	49.9 - 8	53.0 - 6"	56.2 - 5"		
21	51.0 - 9	55.4 - 8	59.0 - 7	62.7 - 6		
22	56.0 - 10	61.0 - 9	65.1 - 8	69.2 - 6		
23	61.7 - 10	67.0 - 9	71.8 - 8	76.6 - 7		
24	67.4 - 11	73.1 - 9	78.5 - 8	83.9 - 7		
25	74.4 - 11	80.8 - 10	86.8 - 9	92.8 - 8		
26	81.4 - 12	88.6 - 11	95.2 - 10	101.7 - 8		
27	88.7 - 12	96.4 - 11	103.6 - 10	110.8 - 9		
28	96.0 - 13	104.2 - 12	112.1 - 11	120.0 - 9	127.2 - 8"	134.4 - 6"
29	103.7 - 13	112.5 - 12	121.2 - 11	130.0 - 10	138.2 - 9	146.4 - 7
30	111.4 - 14	120.9 - 13	130.4 - 11	139.9 - 10	149.1 - 9	158.3 - 8
31	120.3 - 14	130.7 - 13	140.7 - 12	150.7 - 11	160.8 - 9	170.8 - 8
32	129.2 - 15	140.5 - 14	151.0 - 12	161.5 - 11	172.4 - 10	183.3 - 9
33	138.6 - 16	150.6 - 14	161.8 - 13	173.1 - 12	185.0 - 10	197.0 - 9
34	147.8 - 16	160.7 - 15	172.7 - 13	184.7 - 12	197.6 - 11	210.6 - 10
35	158.8 - 17	172.6 - 15	185.5 - 14	198.4 - 13	212.0 - 12	225.5 - 10
36	169.6 - 17	184.4 - 16	198.3 - 15	212.2 - 13	226.3 - 12	240.4 - 11
37	180.2 - 18	195.8 - 17	210.8 - 15	225.9 - 14	240.8 - 13	255.7 - 11
38	190.8 - 19	207.2 - 17	223.4 - 16	239.6 - 15	255.3 - 13	271.0 - 12
39	201.3 - 19	218.9 - 18	235.6 - 16	252.4 - 15	269.1 - 14	285.8 - 12
40	211.8 - 20	230.6 - 18	247.9 - 17	265.2 - 15	282.8 - 14	300.5 - 12

Table 4.--Gross volume (cubic feet, inside bark)
Form Class 67 Trees

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem					
	12	16	20	24	28	32
5	1.1	1.3	1.5	1.7	2.0	2.2
6	1.5	1.8	2.1	2.4	2.7	2.9
7	1.9	2.4	2.8	3.1	3.5	3.9
8	2.5	3.1	3.6	4.0	4.5	4.9
9	3.0	3.8	4.3	4.9	5.4	6.0
10	3.7	4.7	5.3	6.0	6.6	7.2

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs				
	1	1½	2	2½	3
10	4.7 - 7"	6.3 - 6"	7.9 - 5"		
11	5.8 - 7	7.7 - 7	9.6 - 6		
12	6.8 - 8	9.1 - 7	11.4 - 6	13.0 - 6"	14.7 - 5"
13	8.0 - 9	10.8 - 8	13.6 - 7	15.6 - 6	17.6 - 6
14	9.3 - 9	12.5 - 9	15.7 - 8	18.1 - 7	20.5 - 6
15	10.6 - 10	14.3 - 9	18.0 - 8	20.8 - 8	23.6 - 7
16	12.0 - 11	16.2 - 10	20.4 - 9	23.6 - 8	26.8 - 7
17	13.7 - 11	18.5 - 10	23.3 - 9	27.0 - 9	30.8 - 8
18	15.4 - 12	20.8 - 11	26.2 - 10	30.4 - 9	34.7 - 9
19	17.2 - 13	23.3 - 12	29.4 - 11	34.2 - 10	38.9 - 9
20	19.1 - 13	25.8 - 12	32.5 - 11	37.8 - 11	43.1 - 10
21	21.3 - 14	28.7 - 13	36.1 - 12	42.0 - 11	47.8 - 10
22	23.5 - 15	31.6 - 14	39.7 - 12	46.2 - 12	52.6 - 11
23	26.0 - 15	35.0 - 14	44.0 - 13	51.2 - 12	58.4 - 11
24	28.6 - 16	38.4 - 15	48.2 - 14	56.2 - 13	64.1 - 12
25	31.4 - 17	42.0 - 16	52.7 - 14	61.4 - 13	70.0 - 13
26	34.2 - 17	45.7 - 16	57.2 - 15	66.6 - 14	76.0 - 13
27	37.4 - 18	49.9 - 17	62.4 - 16	72.7 - 15	83.0 - 14
28	40.7 - 19	54.2 - 18	67.7 - 16	78.9 - 15	90.1 - 14
29	44.2 - 19	58.7 - 18	73.2 - 17	85.2 - 16	97.3 - 15
30	47.8 - 20	63.3 - 19	78.8 - 17	91.6 - 16	104.5 - 15
31	51.8 - 21	68.8 - 19	85.7 - 18	99.2 - 17	112.7 - 16
32	55.9 - 21	74.2 - 20	92.6 - 19	106.8 - 18	120.9 - 17
33	60.4 - 22	79.6 - 21	98.8 - 19	114.4 - 18	130.0 - 17
34	65.0 - 23	85.0 - 21	105.1 - 20	122.2 - 19	139.2 - 18
35	69.4 - 23	90.7 - 22	112.0 - 21	130.2 - 20	148.4 - 19
36	73.9 - 24	96.4 - 23	119.0 - 21	138.3 - 20	157.6 - 19
37	78.9 - 25	102.8 - 23	126.8 - 22	147.4 - 21	168.1 - 20
38	83.9 - 25	109.2 - 24	134.6 - 23	156.6 - 22	178.6 - 21
39	88.3 - 26	115.0 - 25	141.8 - 23	165.0 - 22	188.1 - 21
40	92.7 - 27	120.8 - 25	149.0 - 24	173.3 - 23	197.6 - 22

Table 4.--Continued

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem						
	36	40	44	48	52	56	60
5	2.4	2.6	2.9	3.1	3.3	3.5	3.8
6	3.2	3.5	3.8	4.1	4.4	4.6	4.9
7	4.2	4.6	5.0	5.3	5.7	6.1	6.4
8	5.4	5.9	6.3	6.8	7.2	7.7	8.2
9	6.5	7.1	7.6	8.2	8.7	9.2	9.8
10	7.9	8.5	9.2	9.8	10.4	11.1	11.7

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs					
	3½	4	4½	5	5½	6
10						
11						
12						
13						
14						
15						
16	29.3 - 7"	31.8 - 6"				
17	33.7 - 7	36.6 - 6				
18	38.0 - 8	41.3 - 7				
19	42.6 - 8	46.2 - 7				
20	47.2 - 9	51.2 - 8	54.5 - 7"	57.8 - 6"		
21	52.4 - 9	57.0 - 8	60.8 - 7	64.6 - 6		
22	57.8 - 10	62.9 - 9	67.2 - 8	71.4 - 7		
23	64.0 - 10	69.5 - 9	74.4 - 8	79.4 - 7		
24	70.1 - 11	76.1 - 10	81.8 - 9	87.5 - 8		
25	76.7 - 11	83.4 - 10	89.6 - 9	95.9 - 8		
26	83.4 - 12	90.8 - 11	97.6 - 10	104.3 - 9		
27	91.0 - 13	99.0 - 11	106.5 - 10	114.0 - 9		
28	98.7 - 13	107.3 - 12	115.6 - 11	123.8 - 10	131.4 - 9"	138.9 - 7"
29	106.6 - 14	115.8 - 12	124.9 - 11	134.0 - 10	142.5 - 9	151.0 - 7
30	114.4 - 14	124.3 - 13	134.2 - 12	144.1 - 11	153.6 - 9	163.2 - 8
31	123.5 - 15	134.3 - 13	144.6 - 12	155.0 - 11	165.4 - 10	175.9 - 9
32	132.6 - 15	144.3 - 14	155.2 - 13	166.0 - 11	177.3 - 10	188.6 - 9
33	142.6 - 16	155.2 - 15	166.9 - 13	178.6 - 12	191.0 - 11	203.4 - 10
34	152.6 - 17	166.1 - 15	178.7 - 14	191.3 - 13	204.8 - 11	218.3 - 10
35	162.8 - 17	177.1 - 16	190.6 - 14	204.1 - 13	218.2 - 12	232.2 - 11
36	172.8 - 18	188.1 - 16	202.5 - 15	216.9 - 14	231.4 - 12	246.0 - 11
37	184.3 - 18	200.5 - 17	216.2 - 16	231.8 - 14	247.2 - 13	262.6 - 12
38	195.8 - 19	212.9 - 18	229.8 - 16	246.6 - 15	262.9 - 14	279.2 - 12
39	206.4 - 20	224.8 - 18	242.2 - 17	259.6 - 15	276.9 - 14	294.2 - 12
40	217.1 - 20	236.6 - 19	254.6 - 17	272.5 - 16	290.8 - 14	309.2 - 13

Table 5.--Gross volume (cubic feet, inside bark)
Form Class 68 Trees

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem					
	12	16	20	24	28	32
5	1.1	1.3	1.5	1.7	2.0	2.2
6	1.5	1.8	2.1	2.4	2.7	3.0
7	2.0	2.5	2.9	3.3	3.7	4.0
8	2.5	3.1	3.6	4.0	4.5	4.9
9	3.0	3.9	4.4	5.0	5.5	6.1
10	3.8	4.8	5.4	6.1	6.7	7.3

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs				
	1	1½	2	2½	3
10	4.8 - 7"	6.4 - 6"	8.1 - 5"		
11	5.8 - 7	7.8 - 7	9.9 - 6		
12	6.9 - 8	9.3 - 7	11.7 - 7	13.5 - 6"	15.3 - 5"
13	8.1 - 9	11.0 - 8	13.8 - 7	15.9 - 7	18.0 - 6
14	9.3 - 9	12.6 - 9	15.9 - 8	18.4 - 7	20.8 - 6
15	10.8 - 10	14.6 - 9	18.5 - 8	21.4 - 8	24.4 - 7
16	12.4 - 11	16.8 - 10	21.1 - 9	24.5 - 8	27.9 - 8
17	14.0 - 12	19.0 - 11	23.9 - 10	27.8 - 9	31.6 - 8
18	15.7 - 12	21.2 - 11	26.7 - 10	31.0 - 9	35.4 - 9
19	17.6 - 13	23.8 - 12	30.0 - 11	34.9 - 10	39.9 - 9
20	19.6 - 14	26.5 - 13	33.4 - 11	38.9 - 11	44.4 - 10
21	21.8 - 14	29.5 - 13	37.2 - 12	43.3 - 11	49.4 - 11
22	24.0 - 15	32.5 - 14	41.0 - 13	47.8 - 12	54.5 - 11
23	26.4 - 16	35.7 - 14	45.0 - 13	52.5 - 13	60.0 - 12
24	28.9 - 16	38.9 - 15	49.0 - 14	57.2 - 13	65.4 - 12
25	31.9 - 17	42.9 - 16	53.9 - 15	62.8 - 14	71.8 - 13
26	34.9 - 18	46.8 - 16	58.8 - 15	68.6 - 14	78.3 - 13
27	38.0 - 18	50.9 - 17	63.8 - 16	74.4 - 15	85.0 - 14
28	41.1 - 19	54.9 - 18	68.7 - 16	80.2 - 16	91.7 - 15
29	44.8 - 20	59.7 - 18	74.6 - 17	87.0 - 16	99.4 - 15
30	48.6 - 20	64.6 - 19	80.6 - 18	93.9 - 17	107.2 - 16
31	52.7 - 21	69.8 - 20	87.0 - 18	101.4 - 17	115.8 - 16
32	56.8 - 22	75.2 - 20	93.5 - 19	109.0 - 18	124.5 - 17
33	60.9 - 22	80.4 - 21	99.9 - 20	116.4 - 19	132.9 - 18
34	65.0 - 23	85.6 - 22	106.3 - 20	123.8 - 19	141.4 - 18
35	70.0 - 24	92.0 - 22	114.0 - 21	132.8 - 20	151.5 - 19
36	74.9 - 24	98.2 - 23	121.6 - 22	141.6 - 21	161.6 - 20
37	79.4 - 25	104.0 - 24	128.7 - 22	150.0 - 21	171.3 - 20
38	83.9 - 26	109.8 - 24	135.8 - 23	158.4 - 22	181.0 - 21
39	88.6 - 26	116.1 - 25	143.6 - 24	167.4 - 23	191.3 - 22
40	93.3 - 27	122.3 - 26	151.3 - 24	176.4 - 23	201.6 - 22

Table 5.--Continued

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem						
	36	40	44	48	52	56	60
5	2.4	2.6	2.9	3.1	3.3	3.5	3.8
6	3.3	3.6	3.9	4.2	4.5	4.8	5.1
7	4.4	4.8	5.2	5.6	6.0	6.3	6.7
8	5.4	5.9	6.3	6.8	7.2	7.7	8.2
9	6.6	7.2	7.7	8.3	8.8	9.3	9.9
10	8.0	8.6	9.3	9.9	10.5	11.2	11.8

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs					
	3½	4	4½	5	5½	6
10						
11						
12						
13						
14						
15						
16	30.5 - 7"	33.1 - 6"				
17	34.6 - 7	37.6 - 6				
18	38.8 - 8	42.1 - 7				
19	43.7 - 8	47.5 - 7				
20	48.6 - 9	52.9 - 8	56.3 - 7"	59.7 - 6"		
21	54.2 - 10	59.1 - 9	63.0 - 7	67.0 - 6		
22	59.9 - 10	65.3 - 9	69.8 - 8	74.4 - 7		
23	65.8 - 11	71.6 - 10	76.8 - 8	82.0 - 7		
24	71.6 - 11	77.8 - 10	83.7 - 9	89.6 - 8		
25	78.8 - 12	85.8 - 11	92.3 - 9	98.8 - 8		
26	86.0 - 12	93.8 - 11	100.9 - 10	108.0 - 9		
27	93.3 - 13	101.6 - 12	109.4 - 11	117.2 - 9		
28	100.6 - 13	109.4 - 12	117.9 - 11	126.4 - 10	134.2 - 8"	141.9 - 7"
29	109.0 - 14	118.6 - 13	128.0 - 12	137.4 - 10	146.2 - 9	155.0 - 8
30	117.5 - 14	127.8 - 13	138.1 - 12	148.4 - 11	158.3 - 10	168.2 - 8
31	127.1 - 15	138.4 - 14	149.3 - 13	160.2 - 11	171.0 - 10	181.8 - 9
32	136.8 - 16	149.0 - 14	160.4 - 13	171.9 - 12	183.7 - 11	195.5 - 9
33	146.0 - 16	159.1 - 15	171.4 - 14	183.6 - 12	196.4 - 11	209.3 - 10
34	155.3 - 17	169.2 - 15	182.2 - 14	195.2 - 13	209.2 - 12	223.1 - 10
35	166.4 - 18	181.4 - 16	195.4 - 15	209.4 - 13	223.9 - 12	238.4 - 11
36	177.6 - 18	193.5 - 17	208.5 - 15	223.5 - 14	238.6 - 13	253.8 - 11
37	188.1 - 19	204.9 - 17	221.1 - 16	237.3 - 15	253.2 - 13	269.2 - 12
38	198.6 - 19	216.3 - 18	233.7 - 17	251.1 - 15	267.9 - 14	284.7 - 12
39	210.2 - 20	229.2 - 19	247.2 - 17	265.2 - 16	283.2 - 14	301.1 - 13
40	221.8 - 21	242.1 - 19	260.8 - 18	279.4 - 16	298.4 - 15	317.5 - 13

Table 6.--Gross volume (cubic feet, inside bark)
Form Class 69 Trees

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem					
	12	16	20	24	28	32
5	1.1	1.3	1.5	1.7	2.0	2.2
6	1.5	1.8	2.1	2.4	2.7	3.0
7	2.0	2.5	2.9	3.3	3.7	4.0
8	2.6	3.2	3.7	4.2	4.6	5.1
9	3.2	4.0	4.6	5.1	5.7	6.3
10	3.8	4.9	5.6	6.2	6.9	7.5

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs				
	1	1½	2	2½	3
10	4.9 - 7"	6.6 - 6"	8.3 - 5"		
11	6.0 - 8	8.1 - 7	10.2 - 6		
12	7.1 - 8	9.6 - 7	12.1 - 7	13.9 - 6"	15.7 - 5"
13	8.4 - 9	11.4 - 8	14.3 - 7	16.5 - 7	18.7 - 6
14	9.6 - 10	13.0 - 9	16.5 - 8	19.1 - 7	21.7 - 7
15	11.0 - 10	15.0 - 9	18.9 - 9	22.0 - 8	25.0 - 7
16	12.4 - 11	16.8 - 10	21.3 - 9	24.8 - 8	28.2 - 8
17	14.2 - 12	19.2 - 11	24.3 - 10	28.2 - 9	32.2 - 8
18	15.9 - 12	21.6 - 11	27.3 - 10	31.8 - 10	36.3 - 9
19	17.9 - 13	24.4 - 12	30.8 - 11	35.8 - 10	40.9 - 10
20	19.9 - 14	27.0 - 13	34.2 - 12	39.8 - 11	45.5 - 10
21	22.1 - 14	30.0 - 13	38.0 - 12	44.3 - 12	50.6 - 11
22	24.3 - 15	33.0 - 14	41.8 - 13	48.8 - 12	55.7 - 11
23	27.0 - 16	36.6 - 15	46.2 - 14	54.0 - 13	61.7 - 12
24	29.6 - 17	40.0 - 15	50.5 - 14	59.1 - 13	67.7 - 13
25	32.4 - 17	43.8 - 16	55.2 - 15	64.5 - 14	73.8 - 13
26	35.3 - 18	47.6 - 17	59.8 - 15	69.8 - 15	79.8 - 14
27	38.6 - 19	51.9 - 17	65.2 - 16	76.1 - 15	87.0 - 14
28	41.9 - 19	56.2 - 18	70.5 - 17	82.4 - 16	94.3 - 15
29	45.4 - 20	60.8 - 19	76.2 - 17	89.0 - 16	101.9 - 15
30	49.0 - 21	65.5 - 19	82.0 - 18	95.8 - 17	109.5 - 16
31	53.1 - 21	70.8 - 20	88.4 - 19	103.3 - 18	118.2 - 17
32	57.2 - 22	76.0 - 21	94.9 - 19	111.0 - 18	127.0 - 17
33	61.8 - 23	82.0 - 21	102.1 - 20	119.2 - 19	136.4 - 18
34	66.5 - 23	87.9 - 22	109.3 - 21	127.6 - 20	145.8 - 19
35	71.0 - 24	93.7 - 23	116.4 - 21	135.8 - 20	155.2 - 19
36	75.4 - 25	99.4 - 23	123.4 - 22	144.0 - 21	164.5 - 20
37	80.2 - 25	105.6 - 24	131.0 - 23	153.0 - 22	174.9 - 21
38	84.9 - 26	111.7 - 25	138.5 - 23	161.9 - 22	185.3 - 21
39	89.7 - 27	118.0 - 25	146.4 - 24	171.1 - 23	195.8 - 22
40	94.5 - 28	124.4 - 26	154.4 - 25	180.4 - 24	206.3 - 23

Table 6.--Continued

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem						
	36	40	44	48	52	56	60
5	2.4	2.6	2.9	3.1	3.3	3.5	3.8
6	3.3	3.6	3.9	4.2	4.5	4.8	5.1
7	4.4	4.8	5.2	5.6	6.0	6.3	6.7
8	5.6	6.1	6.6	7.0	7.5	8.0	8.5
9	6.8	7.4	8.0	8.5	9.1	9.7	10.2
10	8.2	8.9	9.5	10.2	10.8	11.5	12.2

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs					
	3½	4	4½	5	5½	6
10						
11						
12						
13						
14	23.6 - 6"	25.4 - 5"				
15	27.2 - 6	29.5 - 6				
16	30.9 - 7	33.6 - 6				
17	35.3 - 7	38.4 - 7				
18	39.8 - 8	43.3 - 7				
19	44.8 - 9	48.8 - 8				
20	50.0 - 9	54.4 - 8	58.0 - 7"	61.5 - 6"		
21	55.6 - 10	60.6 - 9	64.8 - 8	68.9 - 7		
22	61.3 - 10	66.9 - 9	71.6 - 8	76.3 - 7		
23	67.8 - 11	73.8 - 10	79.2 - 9	84.6 - 8		
24	74.2 - 11	80.7 - 10	86.8 - 9	93.0 - 8		
25	81.0 - 12	88.2 - 11	95.0 - 10	101.7 - 9		
26	87.8 - 13	95.8 - 11	103.1 - 10	110.4 - 9		
27	95.6 - 13	104.2 - 12	112.3 - 11	120.4 - 10		
28	103.5 - 14	112.7 - 12	121.6 - 11	130.4 - 10	138.5 - 9"	146.6 - 7"
29	111.8 - 14	121.8 - 13	131.6 - 12	141.4 - 11	150.6 - 9	159.7 - 8
30	120.2 - 15	130.9 - 13	141.6 - 12	152.3 - 11	162.6 - 10	172.8 - 9
31	129.9 - 15	141.6 - 14	152.9 - 13	164.2 - 12	175.4 - 10	186.6 - 9
32	139.7 - 16	152.4 - 15	164.2 - 13	176.0 - 12	188.2 - 11	200.5 - 10
33	150.0 - 17	163.6 - 15	176.3 - 14	189.0 - 13	202.4 - 12	215.8 - 10
34	160.4 - 17	174.9 - 16	188.5 - 15	202.1 - 13	216.6 - 12	231.2 - 11
35	170.6 - 18	186.1 - 16	200.6 - 15	215.2 - 14	230.3 - 13	245.4 - 11
36	180.9 - 18	197.3 - 17	212.8 - 16	228.3 - 14	244.0 - 13	259.6 - 12
37	192.3 - 19	209.7 - 18	226.4 - 16	243.2 - 15	259.8 - 14	276.4 - 12
38	203.7 - 20	222.1 - 18	240.2 - 17	258.2 - 16	275.6 - 14	293.1 - 13
39	215.5 - 20	235.2 - 19	253.9 - 18	272.6 - 16	291.2 - 15	309.8 - 13
40	227.3 - 21	248.3 - 20	267.6 - 18	287.0 - 17	306.8 - 15	326.5 - 14

Table 7.--Gross volume (cubic feet, inside bark)
Form Class 70 Trees

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem					
	12	16	20	24	28	32
5	1.1	1.4	1.6	1.9	2.1	2.3
6	1.5	1.9	2.2	2.5	2.8	3.2
7	2.1	2.6	3.0	3.4	3.8	4.2
8	2.6	3.4	3.9	4.4	4.9	5.4
9	3.2	4.2	4.8	5.4	6.0	6.6
10	4.0	5.0	5.7	6.4	7.1	7.7

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs				
	1	1½	2	2½	3
10	5.0 - 7"	6.8 - 6"	8.5 - 6"		
11	6.1 - 8	8.2 - 7	10.4 - 6		
12	7.2 - 8	9.8 - 8	12.3 - 7	14.2 - 6"	16.0 - 6"
13	8.5 - 9	11.6 - 8	14.6 - 7	16.8 - 7	19.1 - 6
14	9.8 - 10	13.4 - 9	16.9 - 8	19.6 - 7	22.2 - 7
15	11.3 - 10	15.4 - 10	19.4 - 9	22.6 - 8	25.8 - 7
16	12.8 - 11	17.4 - 10	22.0 - 9	25.6 - 9	29.3 - 8
17	14.6 - 12	19.8 - 11	25.1 - 10	29.2 - 9	33.4 - 9
18	16.4 - 13	22.3 - 12	28.2 - 11	32.9 - 10	37.6 - 9
19	18.4 - 13	25.0 - 12	31.6 - 11	36.9 - 10	42.2 - 10
20	20.4 - 14	27.8 - 13	35.1 - 12	41.0 - 11	46.9 - 10
21	22.6 - 15	30.8 - 14	39.0 - 13	45.6 - 12	52.1 - 11
22	24.9 - 15	33.9 - 14	42.9 - 13	50.1 - 12	57.3 - 12
23	27.6 - 16	37.4 - 15	47.3 - 14	55.3 - 13	63.3 - 12
24	30.2 - 17	41.0 - 16	51.7 - 14	60.5 - 14	69.3 - 13
25	33.1 - 17	44.8 - 16	56.6 - 15	66.2 - 14	75.8 - 13
26	36.0 - 18	48.7 - 17	61.4 - 16	71.8 - 15	82.2 - 14
27	39.3 - 19	53.0 - 18	66.8 - 16	78.2 - 15	89.5 - 15
28	42.6 - 20	57.4 - 18	72.1 - 17	84.4 - 16	96.8 - 15
29	46.2 - 20	62.1 - 19	78.0 - 18	91.3 - 17	104.6 - 16
30	49.8 - 21	66.8 - 20	83.8 - 18	98.0 - 17	112.3 - 16
31	54.0 - 22	72.2 - 20	90.4 - 19	105.8 - 18	121.2 - 17
32	58.1 - 22	77.5 - 21	96.9 - 20	113.4 - 19	130.0 - 18
33	62.6 - 23	83.3 - 22	104.0 - 20	121.6 - 19	139.3 - 18
34	67.0 - 24	89.0 - 22	111.0 - 21	129.8 - 20	148.6 - 19
35	71.4 - 24	94.8 - 23	118.2 - 22	138.3 - 21	158.4 - 20
36	75.9 - 25	100.7 - 24	125.5 - 22	146.8 - 21	168.2 - 20
37	80.7 - 26	107.0 - 24	133.2 - 23	156.0 - 22	178.8 - 21
38	85.5 - 27	113.2 - 25	140.9 - 24	165.1 - 23	189.3 - 22
39	90.2 - 27	119.5 - 26	148.8 - 24	174.3 - 23	199.8 - 22
40	95.0 - 28	125.8 - 27	156.7 - 25	183.6 - 24	210.4 - 23

Table 7.--Continued

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem						
	36	40	44	48	52	56	60
5	2.6	2.8	3.1	3.3	3.5	3.8	4.0
6	3.5	3.8	4.1	4.4	4.7	5.1	5.4
7	4.6	5.0	5.4	5.8	6.2	6.6	7.0
8	5.9	6.4	6.9	7.4	7.9	8.4	8.9
9	7.1	7.7	8.3	8.9	9.5	10.1	10.7
10	8.4	9.1	9.8	10.5	11.2	11.8	12.5

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs					
	3½	4	4½	5	5½	6
10						
11						
12						
13						
14	24.1 - 6"	26.0 - 5"				
15	28.1 - 7	30.4 - 6				
16	32.1 - 7	34.9 - 6				
17	36.6 - 8	39.9 - 7				
18	41.2 - 8	44.9 - 7				
19	46.4 - 9	50.5 - 8				
20	51.5 - 9	56.1 - 8	59.8 - 7"	63.5 - 6"		
21	57.3 - 10	62.5 - 9	66.8 - 8	71.0 - 7		
22	63.1 - 11	68.9 - 10	73.8 - 8	78.6 - 7		
23	69.6 - 11	75.8 - 10	81.4 - 9	87.0 - 8		
24	76.0 - 12	82.7 - 10	89.1 - 9	95.5 - 8		
25	83.3 - 12	90.8 - 11	97.8 - 10	104.8 - 9		
26	90.6 - 13	98.9 - 12	106.6 - 11	114.2 - 9		
27	98.4 - 13	107.4 - 12	115.8 - 11	124.3 - 10		
28	106.4 - 14	116.0 - 13	125.2 - 12	134.4 - 11	142.8 - 9	151.2 - 8"
29	114.9 - 15	125.2 - 13	135.4 - 12	145.6 - 11	155.1 - 10	164.6 - 8
30	123.4 - 15	134.5 - 14	145.6 - 13	156.7 - 12	167.4 - 10	178.0 - 9
31	133.3 - 16	145.4 - 14	157.1 - 13	168.8 - 12	180.4 - 11	192.1 - 9
32	143.2 - 16	156.3 - 15	168.6 - 14	180.8 - 12	193.5 - 11	206.2 - 10
33	153.4 - 17	167.4 - 16	180.6 - 14	193.8 - 13	207.6 - 12	221.5 - 11
34	163.6 - 18	178.6 - 16	192.6 - 15	206.7 - 14	221.8 - 12	236.8 - 11
35	174.4 - 18	190.5 - 17	205.6 - 15	220.6 - 14	236.3 - 13	252.0 - 12
36	185.3 - 19	202.4 - 17	218.5 - 16	234.6 - 15	250.9 - 13	267.2 - 12
37	196.9 - 20	215.0 - 18	232.4 - 17	249.8 - 15	267.0 - 14	284.2 - 13
38	208.4 - 20	227.5 - 19	246.2 - 17	265.0 - 16	283.2 - 15	301.3 - 13
39	220.2 - 21	240.7 - 19	260.2 - 18	279.6 - 17	298.9 - 15	318.2 - 14
40	232.2 - 21	253.9 - 20	274.0 - 19	294.1 - 17	314.6 - 16	335.0 - 14

Table 8.--Gross volume (cubic feet, inside bark)
Form Class 71 Trees

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem					
	12	16	20	24	28	32
5	1.2	1.5	1.8	2.0	2.3	2.5
6	1.6	2.0	2.3	2.7	3.0	3.3
7	2.2	2.7	3.1	3.5	4.0	4.4
8	2.7	3.5	4.0	4.5	5.0	5.5
9	3.4	4.3	4.9	5.5	6.1	6.7
10	4.0	5.2	5.9	6.6	7.3	8.0

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs				
	1	1½	2	2½	3
10	5.2 - 7"	7.0 - 6"	8.8 - 6"		
11	6.3 - 8	8.5 - 7	10.7 - 6		
12	7.4 - 8	10.0 - 8	12.6 - 7	14.6 - 6"	16.5 - 6
13	8.7 - 9	11.8 - 8	14.9 - 8	17.2 - 7	19.6 - 6
14	10.0 - 10	13.6 - 9	17.2 - 8	20.0 - 8	22.7 - 7
15	11.6 - 11	15.8 - 10	20.0 - 9	23.3 - 8	26.6 - 8
16	13.2 - 11	18.0 - 10	22.8 - 9	26.6 - 9	30.4 - 8
17	15.0 - 12	20.5 - 11	26.0 - 10	30.3 - 9	34.6 - 9
18	16.9 - 13	23.0 - 12	29.1 - 11	34.0 - 10	38.9 - 9
19	19.0 - 13	25.8 - 12	32.6 - 11	38.1 - 11	43.6 - 10
20	21.0 - 14	28.6 - 13	36.2 - 12	42.2 - 11	48.3 - 11
21	23.2 - 15	31.6 - 14	40.0 - 13	46.8 - 12	53.6 - 11
22	25.5 - 16	34.7 - 14	43.9 - 13	51.4 - 13	58.8 - 12
23	28.0 - 16	38.1 - 15	48.2 - 14	56.4 - 13	64.7 - 12
24	30.5 - 17	41.5 - 16	52.5 - 15	61.6 - 14	70.6 - 13
25	33.6 - 18	45.6 - 17	57.7 - 15	67.6 - 14	77.6 - 14
26	36.7 - 18	49.8 - 17	62.9 - 16	73.8 - 15	84.6 - 14
27	40.0 - 19	54.2 - 18	68.4 - 17	80.2 - 16	92.0 - 15
28	43.4 - 20	58.6 - 19	73.9 - 17	86.6 - 16	99.4 - 15
29	47.0 - 21	63.4 - 19	79.8 - 18	93.6 - 17	107.3 - 16
30	50.7 - 21	68.2 - 20	85.7 - 19	100.4 - 18	115.2 - 17
31	54.6 - 22	73.3 - 21	92.0 - 19	107.9 - 18	123.8 - 17
32	58.5 - 23	78.4 - 21	98.4 - 20	115.4 - 19	132.5 - 18
33	63.0 - 23	84.2 - 22	105.4 - 21	123.6 - 20	141.8 - 19
34	67.4 - 24	90.0 - 23	112.5 - 21	131.8 - 20	151.2 - 19
35	72.2 - 25	96.3 - 23	120.4 - 22	141.1 - 21	161.8 - 20
36	77.0 - 26	102.6 - 24	128.3 - 23	150.4 - 22	172.5 - 21
37	81.8 - 26	108.9 - 25	136.0 - 23	159.6 - 22	183.2 - 21
38	86.6 - 27	115.2 - 26	143.8 - 24	168.8 - 23	193.8 - 22
39	91.4 - 28	121.6 - 26	151.8 - 25	178.2 - 24	204.5 - 23
40	96.2 - 28	128.0 - 27	159.8 - 25	187.5 - 24	215.2 - 23

Table 8.--Continued

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem						
	36	40	44	48	52	56	60
5	2.8	3.0	3.3	3.5	3.8	4.0	4.3
6	3.7	4.0	4.3	4.7	5.0	5.3	5.7
7	4.8	5.2	5.7	6.1	6.5	6.9	7.4
8	6.0	6.5	7.0	7.5	8.0	8.5	9.0
9	7.2	7.8	8.4	9.0	9.6	10.2	10.8
10	8.7	9.4	10.2	10.9	11.6	12.3	13.0

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs					
	3½	4	4½	5	5½	6
10						
11						
12						
13						
14	24.6 - 6"	26.6 - 5"				
15	29.0 - 7	31.4 - 6				
16	33.3 - 7	36.2 - 6				
17	38.0 - 8	41.4 - 7				
18	42.7 - 8	46.5 - 8				
19	47.9 - 9	52.2 - 8				
20	53.1 - 10	57.9 - 9	61.8 - 7"	65.6 - 6"		
21	59.0 - 10	64.4 - 9	68.8 - 8	73.2 - 7		
22	64.8 - 11	70.8 - 10	75.8 - 9	80.9 - 8		
23	71.2 - 11	77.6 - 10	83.4 - 9	89.3 - 8		
24	77.6 - 12	84.5 - 11	91.1 - 10	97.7 - 9		
25	85.4 - 12	93.2 - 11	100.5 - 10	107.8 - 9		
26	93.3 - 13	102.0 - 12	110.0 - 11	118.0 - 10		
27	101.4 - 14	110.8 - 13	119.6 - 11	128.3 - 10		
28	109.4 - 14	119.5 - 13	129.0 - 12	138.6 - 11	147.4 - 9"	156.1 - 8"
29	118.0 - 15	128.8 - 14	139.4 - 12	149.9 - 11	159.8 - 10	169.7 - 9
30	126.7 - 15	138.2 - 14	149.7 - 13	161.2 - 12	172.2 - 11	183.3 - 9
31	136.4 - 16	149.0 - 15	161.1 - 14	173.2 - 12	185.2 - 11	197.3 - 10
32	146.1 - 17	159.7 - 15	172.4 - 14	185.1 - 13	198.8 - 12	211.3 - 10
33	156.4 - 17	171.0 - 16	184.6 - 15	198.2 - 13	212.5 - 12	226.8 - 11
34	166.7 - 18	182.2 - 16	196.8 - 15	211.3 - 14	226.8 - 13	242.2 - 11
35	178.5 - 19	195.2 - 17	210.8 - 16	226.5 - 15	242.6 - 13	258.8 - 12
36	190.3 - 19	208.1 - 18	224.9 - 16	241.7 - 15	258.6 - 14	275.5 - 13
37	202.0 - 20	220.8 - 18	238.9 - 17	257.0 - 16	274.9 - 14	292.8 - 13
38	213.6 - 21	233.5 - 19	253.0 - 18	272.4 - 16	291.2 - 15	310.1 - 14
39	225.7 - 21	246.9 - 20	267.0 - 18	287.2 - 17	307.2 - 15	327.2 - 14
40	237.8 - 22	260.3 - 20	281.2 - 19	302.0 - 17	323.2 - 16	344.3 - 14

Table 9.--Gross volume (cubic feet, inside bark)
Form Class 72 Trees

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem					
	12	16	20	24	28	32
5	1.2	1.5	1.8	2.0	2.3	2.5
6	1.6	2.0	2.3	2.7	3.0	3.3
7	2.2	2.7	3.1	3.5	4.0	4.4
8	2.8	3.6	4.1	4.6	5.2	5.7
9	3.4	4.4	5.0	5.7	6.3	6.9
10	4.2	5.3	6.0	6.8	7.5	8.2

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs				
	1	1½	2	2½	3
10	5.3 - 7	7.2 - 6"	9.0 - 6"		
11	6.4 - 8	8.7 - 7	11.0 - 6		
12	7.6 - 9	10.3 - 8	13.0 - 7	15.0 - 6"	16.9 - 6
13	9.0 - 9	12.2 - 9	15.4 - 8	17.8 - 7	20.3 - 6
14	10.4 - 10	14.2 - 9	17.9 - 8	20.8 - 8	23.7 - 7
15	11.9 - 11	16.2 - 10	20.6 - 9	24.0 - 8	27.3 - 8
16	13.4 - 11	18.3 - 11	23.2 - 10	27.0 - 9	30.9 - 8
17	15.2 - 12	20.8 - 11	26.5 - 10	31.0 - 10	35.4 - 9
18	17.1 - 13	23.4 - 12	29.8 - 11	34.8 - 10	39.8 - 10
19	19.2 - 14	26.2 - 13	33.3 - 12	39.0 - 11	44.6 - 10
20	21.2 - 14	29.0 - 13	36.8 - 12	43.1 - 12	49.4 - 11
21	23.5 - 15	32.2 - 14	40.8 - 13	47.8 - 12	54.8 - 11
22	25.8 - 16	35.3 - 15	44.8 - 14	52.4 - 13	60.1 - 12
23	28.6 - 17	39.1 - 15	49.6 - 14	58.1 - 13	66.6 - 13
24	31.5 - 17	43.0 - 16	54.4 - 15	63.8 - 14	73.2 - 13
25	34.4 - 18	46.8 - 17	59.3 - 16	69.6 - 15	79.8 - 14
26	37.4 - 19	50.8 - 17	64.2 - 16	75.4 - 15	86.5 - 14
27	40.8 - 19	55.4 - 18	70.0 - 17	82.2 - 16	94.3 - 15
28	44.2 - 20	60.0 - 19	75.7 - 18	88.9 - 17	102.1 - 16
29	47.8 - 21	64.7 - 20	81.6 - 18	95.8 - 17	110.0 - 16
30	51.5 - 22	69.6 - 20	87.6 - 19	102.8 - 18	118.0 - 17
31	55.4 - 22	74.7 - 21	94.0 - 20	110.4 - 19	126.8 - 18
32	59.4 - 23	80.0 - 22	100.5 - 20	118.0 - 19	135.6 - 18
33	63.9 - 24	85.8 - 22	107.8 - 21	126.6 - 20	145.4 - 19
34	68.4 - 24	91.8 - 23	115.1 - 22	135.2 - 21	155.3 - 20
35	73.0 - 25	97.8 - 24	122.6 - 22	144.0 - 21	165.4 - 20
36	77.5 - 26	103.8 - 24	130.1 - 23	152.8 - 22	175.4 - 21
37	82.6 - 27	110.5 - 25	138.4 - 24	162.6 - 23	186.9 - 22
38	87.7 - 27	117.2 - 26	146.7 - 24	172.6 - 23	198.4 - 22
39	92.5 - 28	123.6 - 27	154.8 - 25	182.0 - 24	209.2 - 23
40	97.3 - 29	130.0 - 27	162.8 - 26	191.4 - 25	219.9 - 24

Table 9.—Continued

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem						
	36	40	44	48	52	56	60
5	2.8	3.0	3.3	3.5	3.8	4.0	4.3
6	3.7	4.0	4.3	4.7	5.0	5.3	5.7
7	4.8	5.2	5.7	6.1	6.5	6.9	7.4
8	6.2	6.7	7.3	7.8	8.3	8.8	9.4
9	7.6	8.2	8.9	9.5	10.1	10.8	11.4
10	9.0	9.7	10.4	11.2	11.9	12.6	13.4

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs					
	3½	4	4½	5	5½	6
10						
11						
12						
13						
14	25.8 - 6"	27.8 - 5"				
15	29.8 - 7	32.4 - 6				
16	33.9 - 7	36.9 - 7				
17	38.9 - 8	42.4 - 7				
18	43.8 - 9	47.8 - 8				
19	49.1 - 9	53.6 - 8				
20	54.4 - 10	59.3 - 9	63.4 - 8	67.4 - 7"		
21	60.4 - 10	65.9 - 9	70.6 - 8	75.2 - 7		
22	66.3 - 11	72.5 - 10	77.8 - 9	83.0 - 8		
23	73.4 - 11	80.2 - 10	86.2 - 9	92.3 - 8		
24	80.5 - 12	87.8 - 11	94.7 - 10	101.6 - 9		
25	88.0 - 13	96.1 - 12	103.6 - 10	111.2 - 9		
26	95.4 - 13	104.4 - 12	112.6 - 11	120.7 - 10		
27	104.0 - 14	113.6 - 13	122.7 - 12	131.8 - 11		
28	112.5 - 15	122.9 - 13	132.9 - 12	142.9 - 11	152.0 - 10	161.1 - 8"
29	121.2 - 15	132.3 - 14	143.3 - 13	154.3 - 12	164.6 - 10	174.8 - 9
30	130.0 - 16	141.9 - 14	153.8 - 13	165.7 - 12	177.2 - 11	188.6 - 9
31	139.8 - 16	152.8 - 15	165.3 - 14	177.8 - 13	190.3 - 11	202.8 - 10
32	149.6 - 17	163.7 - 16	176.8 - 14	189.9 - 13	203.5 - 12	217.1 - 11
33	160.5 - 18	175.6 - 16	189.8 - 15	203.9 - 14	218.8 - 12	233.6 - 11
34	171.4 - 18	187.6 - 17	202.8 - 16	217.9 - 14	234.0 - 13	250.2 - 12
35	182.6 - 19	199.8 - 18	216.0 - 16	232.3 - 15	249.1 - 14	265.9 - 12
36	193.8 - 20	212.1 - 18	229.4 - 17	246.7 - 16	264.2 - 14	281.6 - 13
37	206.4 - 20	225.8 - 19	244.6 - 17	263.4 - 16	281.9 - 15	300.4 - 13
38	219.0 - 21	239.6 - 19	259.8 - 18	280.0 - 17	299.6 - 15	319.1 - 14
39	231.2 - 22	253.1 - 20	274.0 - 19	294.9 - 17	315.6 - 16	336.4 - 14
40	243.2 - 22	266.6 - 21	288.2 - 19	309.8 - 18	331.8 - 16	353.7 - 15

Table 10.--Gross volume (cubic feet, inside bark)
Form Class 73 Trees

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem					
	12	16	20	24	28	32
5	1.2	1.5	1.8	2.0	2.3	2.6
6	1.6	2.1	2.4	2.8	3.1	3.5
7	2.2	2.8	3.2	3.6	4.1	4.5
8	2.8	3.6	4.1	4.6	5.2	5.7
9	3.5	4.5	5.1	5.8	6.4	7.0
10	4.2	5.4	6.1	6.9	7.6	8.3

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs				
	1	1½	2	2½	3
10	5.4 - 7"	7.3 - 7"	9.2 - 6"		
11	6.6 - 8	9.0 - 7	11.4 - 7		
12	7.9 - 9	10.7 - 8	13.5 - 7	15.6 - 7	17.8 - 6
13	9.2 - 9	12.6 - 9	15.9 - 8	18.4 - 7	21.0 - 7
14	10.6 - 10	14.4 - 9	18.3 - 8	21.2 - 8	24.2 - 7
15	12.2 - 11	16.7 - 10	21.2 - 9	24.7 - 8	28.2 - 8
16	13.9 - 12	19.0 - 11	24.1 - 10	28.1 - 9	32.1 - 8
17	15.6 - 12	21.4 - 11	27.2 - 10	31.7 - 10	36.2 - 9
18	17.3 - 13	23.8 - 12	30.2 - 11	35.3 - 10	40.4 - 10
19	19.6 - 14	26.8 - 13	34.0 - 12	39.8 - 11	45.6 - 10
20	21.8 - 15	29.8 - 14	37.9 - 12	44.4 - 12	50.9 - 11
21	24.2 - 15	33.2 - 14	42.2 - 13	49.4 - 12	56.7 - 12
22	26.7 - 16	36.6 - 15	46.4 - 14	54.4 - 13	62.5 - 12
23	29.2 - 17	40.0 - 16	50.8 - 15	59.7 - 14	68.6 - 13
24	31.8 - 17	43.5 - 16	55.2 - 15	64.9 - 14	74.6 - 13
25	35.0 - 18	47.8 - 17	60.6 - 16	71.2 - 15	81.8 - 14
26	38.1 - 19	52.0 - 18	65.9 - 17	77.4 - 16	88.9 - 15
27	41.4 - 20	56.4 - 18	71.3 - 17	83.8 - 16	96.4 - 15
28	44.6 - 20	60.6 - 19	76.7 - 18	90.2 - 17	103.8 - 16
29	48.5 - 21	65.8 - 20	83.2 - 19	97.8 - 18	112.4 - 17
30	52.4 - 22	71.0 - 21	89.6 - 19	105.2 - 18	120.9 - 17
31	56.6 - 23	76.6 - 21	96.5 - 20	113.4 - 19	130.4 - 18
32	60.8 - 23	82.1 - 22	103.4 - 21	121.6 - 20	139.9 - 19
33	65.1 - 24	87.8 - 23	110.4 - 21	129.8 - 20	149.3 - 19
34	69.4 - 25	93.4 - 23	117.4 - 22	138.0 - 21	158.7 - 20
35	74.2 - 26	99.8 - 24	125.4 - 23	147.5 - 22	169.6 - 21
36	79.1 - 26	106.2 - 25	133.4 - 23	156.9 - 22	180.4 - 21
37	83.7 - 27	112.4 - 26	141.0 - 24	166.0 - 23	191.0 - 22
38	88.3 - 28	118.4 - 26	148.6 - 25	175.1 - 24	201.6 - 23
39	93.4 - 28	125.3 - 27	157.2 - 26	185.2 - 25	213.2 - 23
40	98.5 - 29	132.2 - 28	165.9 - 26	195.4 - 25	224.9 - 24

Table 10.--Continued

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem						
	36	40	44	48	52	56	60
5	2.8	3.1	3.4	3.6	3.9	4.2	4.4
6	3.8	4.2	4.5	4.9	5.2	5.6	5.9
7	4.9	5.3	5.8	6.2	6.6	7.0	7.5
8	6.2	6.7	7.3	7.8	8.3	8.8	9.4
9	7.7	8.3	9.0	9.6	10.2	10.9	11.5
10	9.1	9.8	10.5	11.3	12.0	12.7	13.5

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs					
	3½	4	4½	5	5½	6
10						
11						
12						
13						
14	26.3 - 6"	28.4 - 5"				
15	30.8 - 7	33.4 - 6				
16	35.2 - 8	38.4 - 7				
17	39.8 - 8	43.4 - 7				
18	44.4 - 9	48.5 - 8				
19	50.2 - 9	54.8 - 8				
20	56.0 - 10	61.2 - 9	65.4 - 8"	69.6 - 7"		
21	62.6 - 11	68.4 - 10	73.2 - 8	78.0 - 7		
22	69.0 - 11	75.5 - 10	81.0 - 9	86.5 - 8		
23	75.6 - 12	82.6 - 11	88.9 - 10	95.2 - 9		
24	82.1 - 12	89.6 - 11	96.7 - 10	103.8 - 9		
25	90.2 - 13	98.6 - 12	106.4 - 11	114.2 - 10		
26	98.2 - 14	107.5 - 12	116.1 - 11	124.7 - 10		
27	106.4 - 14	116.4 - 13	125.8 - 12	135.2 - 11		
28	114.5 - 15	125.2 - 14	135.4 - 12	145.6 - 11	155.0 - 10"	164.3 - 8"
29	123.9 - 15	135.4 - 14	146.7 - 13	158.0 - 12	168.6 - 11	179.2 - 9
30	133.3 - 16	145.7 - 15	158.0 - 14	170.4 - 12	182.2 - 11	194.1 - 10
31	144.0 - 17	157.5 - 15	170.6 - 14	183.6 - 13	196.6 - 12	209.6 - 10
32	154.6 - 17	169.3 - 16	183.0 - 15	196.7 - 13	210.8 - 12	225.0 - 11
33	165.0 - 18	180.6 - 17	195.3 - 15	210.0 - 14	225.4 - 13	240.8 - 12
34	175.4 - 19	192.0 - 17	207.6 - 16	223.3 - 15	239.9 - 13	256.5 - 12
35	187.4 - 19	205.2 - 18	222.0 - 16	238.8 - 16	256.2 - 14	273.6 - 13
36	199.4 - 20	218.5 - 18	236.4 - 17	254.4 - 16	272.6 - 15	290.7 - 13
37	211.1 - 21	231.2 - 19	250.6 - 18	270.0 - 17	289.1 - 15	308.2 - 14
38	222.8 - 21	243.9 - 20	264.7 - 18	285.5 - 17	305.6 - 16	325.6 - 14
39	235.9 - 22	258.6 - 20	280.2 - 19	301.7 - 18	323.0 - 16	344.4 - 15
40	249.0 - 23	273.2 - 21	295.6 - 20	317.9 - 18	340.6 - 17	363.3 - 15

Table 11.--Gross volume (cubic feet, inside bark)
Form Class 74 Trees

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem					
	12	16	20	24	28	32
5	1.2	1.5	1.8	2.0	2.3	2.6
6	1.6	2.1	2.4	2.8	3.1	3.5
7	2.2	2.8	3.2	3.7	4.1	4.6
8	2.8	3.6	4.1	4.7	5.2	5.8
9	3.5	4.5	5.1	5.8	6.4	7.0
10	4.2	5.4	6.2	6.9	7.7	8.4

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs				
	1	1½	2	2½	3
10	5.4 - 7"	7.4 - 7"	9.4 - 6"		
11	6.6 - 8	9.1 - 7	11.6 - 7		
12	7.9 - 9	10.8 - 8	13.7 - 7	15.8 - 6	18.0 - 6
13	9.4 - 10	12.8 - 9	16.2 - 8	18.8 - 7	21.5 - 7
14	10.8 - 10	14.8 - 10	18.8 - 9	21.9 - 8	25.0 - 7
15	12.4 - 11	17.0 - 10	21.6 - 9	25.2 - 9	28.8 - 8
16	13.9 - 12	19.1 - 11	24.3 - 10	28.4 - 9	32.5 - 9
17	15.8 - 13	21.8 - 12	27.7 - 11	32.4 - 10	37.2 - 9
18	17.8 - 13	24.4 - 12	31.1 - 11	36.4 - 11	41.8 - 10
19	20.0 - 14	27.5 - 13	35.0 - 12	41.0 - 11	47.0 - 11
20	22.3 - 15	30.6 - 14	38.9 - 13	45.6 - 12	52.3 - 11
21	24.8 - 16	34.0 - 14	43.2 - 13	50.7 - 13	58.2 - 12
22	27.3 - 16	37.4 - 15	47.6 - 14	55.8 - 13	64.1 - 12
23	30.0 - 17	41.2 - 16	52.4 - 15	61.6 - 14	70.7 - 13
24	32.8 - 18	45.0 - 17	57.1 - 15	67.2 - 15	77.3 - 14
25	35.6 - 18	48.8 - 17	62.0 - 16	73.0 - 15	83.9 - 14
26	38.5 - 19	52.7 - 18	66.9 - 17	78.7 - 16	90.5 - 15
27	42.0 - 20	57.4 - 19	72.8 - 17	85.6 - 17	98.5 - 16
28	45.4 - 21	62.0 - 19	78.6 - 18	92.6 - 17	106.5 - 16
29	49.1 - 21	67.0 - 20	84.8 - 19	99.9 - 18	115.0 - 17
30	52.8 - 22	72.0 - 21	91.1 - 20	107.2 - 19	123.4 - 18
31	57.0 - 23	77.6 - 22	98.1 - 20	115.6 - 19	133.0 - 18
32	61.3 - 24	83.2 - 22	105.1 - 21	123.9 - 20	142.7 - 19
33	65.8 - 24	89.2 - 23	112.6 - 22	132.7 - 21	152.8 - 20
34	70.4 - 25	95.2 - 24	120.0 - 22	141.4 - 21	162.8 - 20
35	75.0 - 26	101.3 - 24	127.6 - 23	150.4 - 22	173.1 - 21
36	79.6 - 27	107.4 - 25	135.2 - 24	159.3 - 23	183.4 - 22
37	84.5 - 27	114.0 - 26	143.4 - 24	169.1 - 23	194.8 - 22
38	89.4 - 28	120.5 - 27	151.6 - 25	179.0 - 24	206.3 - 23
39	94.6 - 29	127.4 - 27	160.3 - 26	189.2 - 25	218.1 - 24
40	99.7 - 30	134.4 - 28	169.0 - 27	199.4 - 26	229.9 - 25

Table 11.--Continued

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem						
	36	40	44	48	52	56	60
5	2.8	3.1	3.4	3.6	3.9	4.2	4.4
6	3.8	4.2	4.5	4.9	5.2	5.6	5.9
7	5.0	5.4	5.9	6.3	6.8	7.2	7.6
8	6.3	6.9	7.4	8.0	8.5	9.0	9.6
9	7.7	8.3	9.0	9.6	10.2	10.9	11.5
10	9.2	10.0	10.7	11.5	12.2	13.0	13.8

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs					
	3½	4	4½	5	5½	6
10						
11						
12						
13						
14	27.2 - 7"	29.5 - 6"				
15	31.5 - 7	34.2 - 6				
16	35.7 - 8	38.9 - 7				
17	40.9 - 8	44.6 - 7				
18	46.0 - 9	50.2 - 8				
19	51.8 - 10	56.6 - 9				
20	57.6 - 10	63.0 - 9	67.4 - 8"	71.7 - 7"		
21	64.2 - 11	70.2 - 10	75.2 - 8	80.3 - 8		
22	70.8 - 11	77.5 - 10	83.2 - 9	88.9 - 8		
23	78.0 - 12	85.2 - 11	91.8 - 10	98.4 - 9		
24	85.1 - 13	92.9 - 11	100.4 - 10	107.8 - 9		
25	92.6 - 13	101.3 - 12	109.4 - 11	117.6 - 10		
26	100.1 - 14	109.7 - 13	118.5 - 12	127.3 - 10		
27	108.8 - 14	119.2 - 13	128.9 - 12	138.6 - 11		
28	117.6 - 15	128.7 - 14	139.3 - 13	149.9 - 12	159.6 - 10"	169.3 - 9"
29	127.0 - 16	138.9 - 14	150.6 - 13	162.2 - 12	173.2 - 11	184.2 - 9
30	136.2 - 16	149.1 - 15	161.8 - 14	174.6 - 13	186.9 - 11	199.2 - 10
31	147.0 - 17	161.0 - 16	174.5 - 14	188.0 - 13	201.4 - 12	214.8 - 11
32	157.8 - 18	173.0 - 16	187.2 - 15	201.3 - 14	215.9 - 13	230.5 - 11
33	169.0 - 18	185.2 - 17	200.4 - 16	215.7 - 14	231.6 - 13	247.6 - 12
34	180.2 - 19	197.5 - 18	213.8 - 16	230.1 - 15	247.4 - 14	264.7 - 13
35	191.6 - 20	210.0 - 18	227.4 - 17	244.8 - 16	262.8 - 14	280.8 - 13
36	203.0 - 20	222.6 - 19	241.1 - 17	259.6 - 16	278.2 - 15	296.9 - 14
37	215.6 - 21	236.4 - 19	256.4 - 18	276.4 - 17	296.1 - 16	315.8 - 14
38	228.2 - 22	250.2 - 20	271.7 - 19	293.2 - 18	314.0 - 16	334.8 - 15
39	241.6 - 22	265.0 - 21	287.3 - 20	309.6 - 18	331.8 - 17	354.0 - 15
40	254.8 - 23	279.8 - 22	303.0 - 20	326.1 - 19	349.6 - 17	373.1 - 16

Table 12.--Gross volume (cubic feet, inside bark)
Form Class 75 Trees

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem					
	12	16	20	24	28	32
5	1.3	1.6	1.9	2.1	2.4	2.7
6	1.7	2.2	2.5	2.9	3.2	3.6
7	2.2	2.8	3.3	3.7	4.2	4.6
8	2.9	3.7	4.3	4.8	5.4	6.0
9	3.6	4.7	5.4	6.1	6.8	7.4
10	4.3	5.6	6.4	7.2	8.0	8.7

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs				
	1	1½	2	2½	3
10	5.6 - 7	7.6 - 7"	9.7 - 6		
11	6.8 - 8	9.3 - 7	11.8 - 7		
12	8.0 - 9	11.0 - 8	13.9 - 7	16.2 - 7"	18.4 - 6
13	9.4 - 10	13.0 - 9	16.5 - 8	19.2 - 7	21.9 - 7
14	10.9 - 10	15.0 - 10	19.1 - 9	22.2 - 8	25.4 - 7
15	12.6 - 11	17.3 - 10	22.0 - 9	25.8 - 9	29.5 - 8
16	14.3 - 12	19.6 - 11	25.0 - 10	29.3 - 9	33.6 - 9
17	16.2 - 13	22.3 - 12	28.4 - 11	33.3 - 10	38.2 - 9
18	18.1 - 13	25.0 - 12	31.8 - 11	37.4 - 11	42.9 - 10
19	20.4 - 14	28.1 - 13	35.8 - 12	42.0 - 11	48.2 - 11
20	22.6 - 15	31.2 - 14	39.7 - 13	46.6 - 12	53.5 - 11
21	25.1 - 16	34.6 - 15	44.0 - 14	51.7 - 13	59.4 - 12
22	27.6 - 16	38.0 - 15	48.4 - 14	56.9 - 13	65.4 - 13
23	30.4 - 17	41.8 - 16	53.2 - 15	62.6 - 14	72.1 - 13
24	33.2 - 18	45.6 - 17	58.1 - 16	68.4 - 15	78.8 - 14
25	36.2 - 19	49.8 - 18	63.4 - 16	74.6 - 15	85.9 - 15
26	39.2 - 19	53.9 - 18	68.6 - 17	80.8 - 16	93.0 - 15
27	42.7 - 20	58.6 - 19	74.5 - 18	87.8 - 17	101.2 - 16
28	46.2 - 21	63.3 - 20	80.4 - 18	94.8 - 18	109.3 - 17
29	50.0 - 22	68.4 - 20	86.8 - 19	102.3 - 18	117.8 - 17
30	53.7 - 22	73.4 - 21	93.1 - 20	109.8 - 19	126.4 - 18
31	58.0 - 23	79.0 - 22	100.1 - 21	118.1 - 20	136.1 - 19
32	62.2 - 24	84.6 - 23	107.1 - 21	126.4 - 20	145.8 - 19
33	66.8 - 25	90.8 - 23	114.7 - 22	135.4 - 21	156.0 - 20
34	71.4 - 26	96.8 - 24	122.3 - 23	144.2 - 22	166.2 - 21
35	76.0 - 26	103.1 - 25	130.2 - 23	153.6 - 22	177.0 - 21
36	80.6 - 27	109.3 - 26	138.0 - 24	162.9 - 23	187.8 - 22
37	85.6 - 28	115.9 - 26	146.2 - 25	172.8 - 24	199.4 - 23
38	90.5 - 28	122.5 - 27	154.5 - 26	182.8 - 25	211.1 - 24
39	95.7 - 29	129.6 - 28	163.4 - 26	193.2 - 25	223.0 - 24
40	100.9 - 30	136.6 - 29	172.2 - 27	203.6 - 26	234.9 - 25

Table 12.--Continued

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem						
	36	40	44	48	52	56	60
5	2.9	3.2	3.5	3.7	4.0	4.3	4.5
6	3.9	4.3	4.6	5.0	5.3	5.7	6.0
7	5.1	5.6	6.0	6.5	6.9	7.4	7.9
8	6.5	7.1	7.7	8.2	8.8	9.4	9.9
9	8.1	8.8	9.5	10.2	10.9	11.5	12.2
10	9.5	10.3	11.1	11.9	12.7	13.4	14.2

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs					
	3½	4	4½	5	5½	6
10						
11						
12						
13						
14	27.7 - 7"	30.0 - 6"				
15	32.4 - 7	35.2 - 6				
16	37.0 - 8	40.3 - 7				
17	42.1 - 9	46.0 - 8				
18	47.3 - 9	51.7 - 8				
19	53.2 - 10	58.2 - 9				
20	59.0 - 10	64.6 - 9	69.1 - 8"	73.6 - 7"		
21	65.7 - 11	72.0 - 10	77.2 - 9	82.4 - 8		
22	72.4 - 12	79.3 - 11	85.2 - 10	91.1 - 8		
23	79.6 - 12	87.1 - 11	93.9 - 10	100.7 - 9		
24	86.8 - 13	94.9 - 12	102.6 - 11	110.3 - 10		
25	94.9 - 13	103.9 - 12	112.4 - 11	120.8 - 10		
26	103.0 - 14	112.9 - 13	122.1 - 12	131.3 - 11		
27	111.9 - 15	122.6 - 14	132.7 - 12	142.8 - 11		
28	120.8 - 15	132.3 - 14	143.3 - 13	154.3 - 12	164.4 - 10	174.5 - 9"
29	130.2 - 16	142.6 - 15	154.7 - 14	166.8 - 13	178.2 - 11	189.6 - 10
30	139.7 - 17	153.0 - 15	166.2 - 14	179.4 - 13	192.1 - 12	204.8 - 10
31	150.6 - 17	165.0 - 16	179.0 - 15	192.9 - 14	206.8 - 12	220.7 - 11
32	161.4 - 18	177.1 - 17	191.8 - 15	206.4 - 14	221.5 - 13	236.6 - 12
33	172.8 - 19	189.6 - 17	205.3 - 16	221.0 - 15	237.4 - 13	253.8 - 12
34	184.1 - 19	202.0 - 18	218.8 - 17	235.6 - 15	253.4 - 14	271.1 - 13
35	196.1 - 20	215.2 - 19	233.2 - 17	251.2 - 16	269.8 - 15	288.4 - 13
36	208.2 - 21	228.5 - 19	247.7 - 18	266.9 - 17	286.2 - 15	305.6 - 14
37	221.0 - 21	242.5 - 20	263.2 - 19	284.0 - 17	304.4 - 16	324.9 - 15
38	233.8 - 22	256.5 - 21	278.8 - 19	301.0 - 18	322.6 - 17	344.2 - 15
39	247.2 - 23	271.5 - 21	294.6 - 20	317.7 - 19	340.6 - 17	363.6 - 16
40	260.7 - 23	286.5 - 22	310.4 - 21	334.4 - 19	358.7 - 18	383.0 - 16

Table 13.--Gross volume (cubic feet, inside bark)
Form Class 76 Trees

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem					
	12	16	20	24	28	32
5	1.3	1.6	1.9	2.2	2.5	2.7
6	1.8	2.3	2.7	3.0	3.4	3.8
7	2.3	2.9	3.4	3.8	4.3	4.7
8	3.0	3.8	4.4	5.0	5.6	6.2
9	3.6	4.7	5.4	6.1	6.8	7.4
10	4.4	5.7	6.5	7.3	8.1	8.9

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs				
	1	1½	2	2½	3
10	5.7 - 8	7.8 - 7"	9.9 - 6"	11.4 - 6	12.9 - 5
11	7.0 - 8	9.6 - 8	12.1 - 7	14.0 - 6	15.9 - 6
12	8.2 - 9	11.2 - 8	14.3 - 7	16.6 - 7	18.9 - 6
13	9.6 - 10	13.2 - 9	16.9 - 8	19.6 - 8	22.4 - 7
14	11.1 - 11	15.3 - 10	19.5 - 9	22.7 - 8	25.9 - 8
15	13.0 - 11	17.8 - 10	22.7 - 10	26.6 - 9	30.4 - 8
16	14.8 - 12	20.4 - 11	25.9 - 10	30.4 - 10	34.8 - 9
17	16.7 - 13	23.0 - 12	29.4 - 11	34.4 - 10	39.5 - 10
18	18.6 - 14	25.7 - 13	32.8 - 12	38.5 - 11	44.2 - 10
19	20.9 - 14	28.8 - 13	36.8 - 12	43.2 - 12	49.6 - 11
20	23.2 - 15	32.0 - 14	40.8 - 13	48.0 - 12	55.1 - 12
21	25.8 - 16	35.5 - 15	45.2 - 14	53.2 - 13	61.1 - 12
22	28.3 - 17	39.0 - 16	49.6 - 14	58.4 - 14	67.1 - 13
23	31.1 - 17	42.8 - 16	54.5 - 15	64.2 - 14	73.8 - 14
24	33.9 - 18	46.6 - 17	59.4 - 16	70.0 - 15	80.6 - 14
25	37.1 - 19	51.0 - 18	65.0 - 17	76.6 - 16	88.3 - 15
26	40.3 - 20	55.4 - 19	70.6 - 17	83.3 - 16	96.0 - 16
27	43.8 - 21	60.2 - 19	76.6 - 18	90.4 - 17	104.2 - 16
28	47.4 - 21	65.0 - 20	82.6 - 19	97.6 - 18	112.5 - 17
29	51.2 - 22	70.1 - 21	89.0 - 20	105.1 - 19	121.2 - 18
30	55.0 - 23	75.2 - 21	95.5 - 20	112.7 - 19	129.9 - 18
31	59.1 - 24	80.8 - 22	102.4 - 21	121.0 - 20	139.5 - 19
32	63.2 - 24	86.2 - 23	109.3 - 22	129.2 - 21	149.1 - 20
33	67.6 - 25	92.1 - 24	116.6 - 22	137.9 - 21	159.2 - 20
34	71.9 - 26	98.0 - 24	124.0 - 23	146.6 - 22	169.2 - 21
35	76.8 - 27	104.6 - 25	132.4 - 24	156.6 - 23	180.8 - 22
36	81.7 - 27	111.3 - 26	140.9 - 25	166.6 - 24	192.4 - 22
37	86.6 - 28	117.9 - 27	149.2 - 25	176.6 - 24	204.1 - 23
38	91.6 - 29	124.6 - 27	157.5 - 26	186.6 - 25	215.8 - 24
39	96.8 - 30	131.6 - 28	166.4 - 27	197.2 - 26	227.9 - 25
40	102.1 - 30	138.8 - 29	175.4 - 27	207.7 - 26	240.0 - 25

Table 13.--Continued

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem						
	36	40	44	48	52	56	60
5	3.0	3.3	3.6	3.9	4.2	4.4	4.7
6	4.1	4.5	4.9	5.2	5.6	6.0	6.3
7	5.2	5.7	6.1	6.6	7.0	7.5	8.0
8	6.7	7.3	7.9	8.5	9.1	9.7	10.3
9	8.1	8.8	9.5	10.2	10.9	11.5	12.2
10	9.8	10.6	11.4	12.2	13.0	13.8	14.6

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs					
	3½	4	4½	5	5½	6
10						
11						
12						
13						
14	28.3 - 7"	30.7 - 6				
15	33.4 - 7	36.3 - 7				
16	38.4 - 8	41.9 - 7				
17	43.6 - 9	47.6 - 8				
18	48.8 - 9	53.4 - 8				
19	54.8 - 10	60.0 - 9				
20	60.8 - 11	66.5 - 10	71.2 - 8	75.9 - 7"		
21	67.6 - 11	74.0 - 10	79.4 - 9	84.8 - 8		
22	74.2 - 12	81.4 - 11	87.5 - 10	93.6 - 9		
23	81.6 - 12	89.3 - 11	96.3 - 10	103.3 - 9		
24	88.9 - 13	97.2 - 12	105.1 - 11	113.0 - 10		
25	97.6 - 14	107.0 - 13	115.7 - 11	124.4 - 10		
26	106.4 - 14	116.7 - 13	126.2 - 12	135.8 - 11		
27	115.4 - 15	126.6 - 14	137.0 - 13	147.5 - 12		
28	124.4 - 16	136.4 - 14	147.8 - 13	159.2 - 12	169.6 - 11	180.1 - 9"
29	134.0 - 16	146.8 - 15	159.4 - 14	172.0 - 13	183.8 - 11	195.5 - 10
30	143.6 - 17	157.3 - 16	171.0 - 14	184.7 - 13	197.8 - 12	210.9 - 11
31	154.4 - 18	169.4 - 16	183.8 - 15	198.2 - 14	212.5 - 13	226.8 - 11
32	165.2 - 18	181.4 - 17	196.5 - 16	211.6 - 14	227.2 - 13	242.7 - 12
33	176.4 - 19	193.7 - 18	209.9 - 16	226.1 - 15	243.0 - 14	260.0 - 13
34	187.6 - 20	206.0 - 18	223.3 - 17	240.6 - 16	258.9 - 14	277.2 - 13
35	200.6 - 20	220.3 - 19	239.0 - 18	257.6 - 16	276.8 - 15	295.9 - 14
36	213.5 - 21	234.6 - 20	254.6 - 18	274.5 - 17	294.6 - 16	314.6 - 14
37	226.4 - 22	248.7 - 20	270.2 - 19	291.8 - 18	313.0 - 16	334.1 - 15
38	239.3 - 22	262.8 - 21	285.9 - 20	309.0 - 18	331.3 - 17	353.6 - 15
39	253.0 - 23	278.0 - 22	302.0 - 20	325.9 - 19	349.6 - 17	373.3 - 16
40	266.6 - 24	293.3 - 22	318.0 - 21	342.8 - 19	367.9 - 18	393.0 - 16

Table 14.--Gross volume (cubic feet, inside bark)
Form Class 77 Trees

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem					
	12	16	20	24	28	32
5	1.3	1.6	1.9	2.2	2.5	2.7
6	1.8	2.3	2.7	3.0	3.4	3.8
7	2.4	3.0	3.5	4.0	4.4	4.9
8	3.0	3.9	4.5	5.1	5.7	6.3
9	3.7	4.8	5.5	6.3	7.0	7.7
10	4.5	5.9	6.7	7.6	8.4	9.3

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs				
	1	1½	2	2½	3
10	5.9 - 8"	8.0 - 7"	10.2 - 6"	11.8 - 6"	13.3 - 5"
11	7.2 - 8	9.8 - 8	12.4 - 7	14.4 - 6	16.3 - 6
12	8.4 - 9	11.5 - 8	14.6 - 8	17.0 - 7	19.3 - 6
13	10.0 - 10	13.7 - 9	17.4 - 8	20.3 - 8	23.2 - 7
14	11.5 - 11	15.8 - 10	20.2 - 9	23.6 - 8	27.0 - 8
15	13.2 - 12	18.2 - 11	23.2 - 10	27.2 - 9	31.2 - 8
16	15.0 - 12	20.6 - 11	26.3 - 10	30.8 - 10	35.4 - 9
17	17.0 - 13	23.5 - 12	30.0 - 11	35.2 - 10	40.4 - 10
18	19.1 - 14	26.4 - 13	33.7 - 12	39.6 - 11	45.5 - 10
19	21.3 - 15	29.4 - 14	37.6 - 13	44.2 - 12	50.9 - 11
20	23.5 - 15	32.6 - 14	41.6 - 13	49.0 - 13	56.3 - 12
21	26.0 - 16	36.0 - 15	46.0 - 14	54.2 - 13	62.4 - 12
22	28.6 - 17	39.6 - 16	50.5 - 15	59.5 - 14	68.5 - 13
23	31.6 - 18	43.7 - 17	55.8 - 15	65.8 - 15	75.8 - 14
24	34.6 - 18	47.8 - 17	61.0 - 16	72.0 - 15	83.0 - 14
25	37.6 - 19	52.0 - 18	66.4 - 17	78.4 - 16	90.3 - 15
26	40.7 - 20	56.2 - 19	71.7 - 18	84.6 - 17	97.6 - 16
27	44.4 - 21	61.2 - 20	78.1 - 18	92.2 - 17	106.4 - 16
28	48.2 - 22	66.4 - 20	84.5 - 19	99.9 - 18	115.3 - 17
29	52.0 - 22	71.5 - 21	91.0 - 20	107.6 - 19	124.2 - 18
30	55.9 - 23	76.7 - 22	97.5 - 20	115.2 - 19	133.0 - 18
31	60.0 - 24	82.2 - 22	104.4 - 21	123.6 - 20	142.7 - 19
32	64.1 - 25	87.8 - 23	111.4 - 22	131.9 - 21	152.4 - 20
33	68.8 - 25	94.0 - 24	119.3 - 23	141.2 - 22	163.2 - 21
34	73.4 - 26	100.3 - 25	127.2 - 23	150.6 - 22	174.0 - 21
35	78.1 - 27	106.6 - 26	135.2 - 24	160.1 - 23	185.0 - 22
36	82.8 - 28	113.0 - 26	143.3 - 25	169.7 - 24	196.1 - 23
37	88.0 - 28	120.1 - 27	152.2 - 26	180.4 - 25	208.7 - 24
38	93.3 - 29	127.2 - 28	161.2 - 26	191.2 - 25	221.3 - 24
39	98.3 - 30	134.2 - 29	170.0 - 27	201.6 - 26	233.2 - 25
40	103.3 - 31	141.0 - 29	178.7 - 28	211.9 - 27	245.1 - 26

Table 14.--Continued

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem						
	36	40	44	48	52	56	60
5	3.0	3.3	3.6	3.9	4.2	4.4	4.7
6	4.1	4.5	4.9	5.2	5.6	6.0	6.3
7	5.4	5.9	6.4	6.8	7.3	7.8	8.3
8	7.0	7.6	8.2	8.8	9.4	10.0	10.6
9	8.5	9.2	9.9	10.7	11.4	12.1	12.9
10	10.1	10.9	11.8	12.6	13.5	14.3	15.1

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs					
	3½	4	4½	5	5½	6
10						
11						
12						
13						
14	29.5 - 7"	32.0 - 6"				
15	34.2 - 8	37.3 - 7				
16	39.0 - 8	42.6 - 7				
17	44.6 - 9	48.8 - 8				
18	50.3 - 10	55.1 - 9				
19	56.2 - 10	61.6 - 9				
20	62.2 - 11	68.1 - 10	73.0 - 9"	77.9 - 8"		
21	69.0 - 11	75.6 - 10	81.2 - 9	86.8 - 8		
22	75.8 - 12	83.2 - 11	89.5 - 10	95.8 - 9		
23	83.8 - 13	91.8 - 12	99.0 - 11	106.3 - 9		
24	91.7 - 13	100.4 - 12	108.6 - 11	116.8 - 10		
25	100.0 - 14	109.6 - 13	118.6 - 12	127.6 - 11		
26	108.2 - 15	118.9 - 13	128.7 - 12	138.5 - 11		
27	118.0 - 15	129.5 - 14	140.3 - 13	151.1 - 12		
28	127.7 - 16	140.1 - 15	151.9 - 14	163.7 - 13	174.6 - 11"	185.4 - 10"
29	137.4 - 17	150.7 - 15	163.6 - 14	176.6 - 13	188.8 - 12	201.0 - 10
30	147.2 - 17	161.3 - 16	175.4 - 15	189.6 - 14	203.2 - 12	216.7 - 11
31	158.0 - 18	173.4 - 17	188.3 - 15	203.2 - 14	218.0 - 13	232.8 - 12
32	169.0 - 19	185.6 - 17	201.2 - 16	216.9 - 15	232.9 - 13	248.9 - 12
33	181.1 - 19	199.0 - 18	215.8 - 17	232.6 - 15	250.1 - 14	267.6 - 13
34	193.2 - 20	212.3 - 19	230.2 - 17	248.2 - 16	267.2 - 15	286.2 - 14
35	205.4 - 21	225.9 - 19	245.2 - 18	264.4 - 17	284.2 - 15	304.0 - 14
36	217.8 - 21	239.5 - 20	260.0 - 19	280.5 - 17	301.1 - 16	321.7 - 15
37	231.7 - 22	254.7 - 21	276.8 - 19	299.0 - 18	320.9 - 17	342.8 - 15
38	245.6 - 23	269.9 - 21	293.8 - 20	317.6 - 19	340.7 - 17	363.8 - 16
39	259.1 - 24	285.0 - 22	309.7 - 21	334.4 - 19	359.0 - 18	383.5 - 16
40	272.6 - 24	300.2 - 23	325.8 - 21	351.3 - 20	377.2 - 18	403.2 - 17

Table 15.--Gross volume (cubic feet, inside bark)
Form Class 78 Trees

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem					
	12	16	20	24	28	32
5	1.3	1.7	2.0	2.3	2.6	2.9
6	1.8	2.4	2.8	3.2	3.6	3.9
7	2.4	3.1	3.6	4.1	4.6	5.1
8	3.0	3.9	4.5	5.1	5.7	6.3
9	3.8	4.9	5.6	6.4	7.1	7.8
10	4.6	6.0	6.8	7.7	8.5	9.4

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs				
	1	1½	2	2½	3
10	6.0 - 8"	8.2 - 7"	10.4 - 6"	12.0 - 6"	13.6 - 5"
11	7.4 - 9	10.1 - 8	12.8 - 7	14.8 - 6	16.9 - 6
12	8.7 - 9	12.0 - 9	15.2 - 8	17.7 - 7	20.2 - 7
13	10.2 - 10	14.0 - 9	17.9 - 8	20.8 - 8	23.8 - 7
14	11.7 - 11	16.2 - 10	20.6 - 9	24.0 - 9	27.5 - 8
15	13.6 - 12	18.7 - 11	23.8 - 10	27.9 - 9	32.0 - 9
16	15.4 - 12	21.2 - 12	27.1 - 11	31.8 - 10	36.6 - 9
17	17.4 - 13	24.0 - 12	30.6 - 11	36.0 - 11	41.4 - 10
18	19.4 - 14	26.8 - 13	34.2 - 12	40.2 - 11	46.3 - 11
19	21.7 - 15	30.0 - 14	38.4 - 13	45.2 - 12	52.0 - 11
20	24.0 - 16	33.3 - 15	42.6 - 13	50.2 - 13	57.8 - 12
21	26.8 - 16	37.1 - 15	47.4 - 14	55.9 - 13	64.4 - 13
22	29.6 - 17	41.0 - 16	52.3 - 15	61.6 - 14	71.0 - 13
23	32.4 - 18	44.8 - 17	57.3 - 16	67.6 - 15	78.0 - 14
24	35.3 - 19	48.8 - 18	62.3 - 16	73.6 - 16	84.9 - 15
25	38.6 - 19	53.4 - 18	68.1 - 17	80.4 - 16	92.8 - 15
26	41.9 - 20	57.9 - 19	73.9 - 18	87.3 - 17	100.7 - 16
27	45.2 - 21	62.5 - 20	79.8 - 19	94.4 - 18	108.9 - 17
28	48.6 - 22	67.1 - 21	85.6 - 19	101.4 - 18	117.1 - 17
29	52.7 - 23	72.6 - 21	92.6 - 20	109.6 - 19	126.6 - 18
30	56.8 - 23	78.2 - 22	99.6 - 21	117.8 - 20	136.1 - 19
31	61.2 - 24	84.1 - 23	107.0 - 22	126.8 - 21	146.5 - 20
32	65.5 - 25	90.0 - 24	114.5 - 22	135.7 - 21	156.9 - 20
33	70.0 - 26	96.0 - 24	122.0 - 23	144.6 - 22	167.2 - 21
34	74.4 - 26	102.0 - 25	129.6 - 24	153.6 - 23	177.5 - 22
35	79.4 - 27	108.8 - 26	138.2 - 24	163.8 - 23	189.4 - 22
36	84.4 - 28	115.6 - 27	146.8 - 25	174.0 - 24	201.3 - 23
37	89.4 - 29	122.4 - 27	155.3 - 26	184.4 - 25	213.4 - 24
38	94.5 - 30	129.2 - 28	163.8 - 27	194.6 - 26	225.4 - 25
39	99.8 - 30	136.5 - 29	173.2 - 27	205.7 - 26	238.2 - 25
40	105.1 - 31	143.8 - 30	182.5 - 28	216.7 - 27	250.9 - 26

Table 15.--Continued

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem						
	36	40	44	48	52	56	60
5	3.2	3.5	3.8	4.1	4.4	4.7	5.0
6	4.3	4.7	5.1	5.5	5.9	6.2	6.6
7	5.6	6.1	6.6	7.1	7.6	8.1	8.6
8	7.0	7.6	8.2	8.8	9.4	10.0	10.6
9	8.6	9.3	10.0	10.8	11.5	12.2	13.0
10	10.2	11.0	11.9	12.7	13.6	14.4	15.2

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs					
	3½	4	4½	5	5½	6
10						
11						
12	22.0 - 6"	23.8 - 5"				
13	26.0 - 5	28.2 - 6				
14	30.0 - 7	32.6 - 6				
15	35.2 - 8	38.4 - 7				
16	40.4 - 8	44.1 - 8				
17	45.7 - 9	50.0 - 8				
18	51.2 - 10	56.0 - 9				
19	57.5 - 10	63.0 - 9				
20	63.9 - 11	70.0 - 10	75.0 - 9"	80.1 - 8"		
21	71.3 - 12	78.2 - 11	84.0 - 10	89.9 - 8		
22	78.8 - 12	86.5 - 11	93.1 - 10	99.7 - 9		
23	86.3 - 13	94.6 - 12	102.2 - 11	109.7 - 10		
24	93.8 - 14	102.7 - 12	111.2 - 11	119.7 - 10		
25	102.8 - 14	112.8 - 13	122.1 - 12	131.4 - 11		
26	111.8 - 15	122.8 - 14	133.0 - 13	143.2 - 12		
27	120.8 - 16	132.6 - 14	143.8 - 13	155.0 - 12		
28	129.8 - 16	142.4 - 15	154.6 - 14	166.7 - 13	177.8 - 11	188.8 - 10"
29	140.2 - 17	153.9 - 16	167.2 - 14	180.6 - 13	193.2 - 12	205.7 - 11
30	150.8 - 17	165.4 - 16	180.0 - 15	194.6 - 14	208.6 - 13	222.6 - 11
31	162.5 - 18	178.5 - 17	194.0 - 16	209.4 - 15	224.7 - 13	240.0 - 12
32	174.2 - 19	191.6 - 18	207.8 - 16	224.1 - 15	240.8 - 14	257.4 - 13
33	185.7 - 20	204.2 - 18	221.6 - 17	239.0 - 16	257.1 - 14	275.2 - 13
34	197.2 - 20	216.9 - 19	235.4 - 18	253.9 - 16	273.4 - 15	293.0 - 14
35	210.5 - 21	231.6 - 20	251.4 - 18	271.3 - 17	291.8 - 16	312.2 - 14
36	223.8 - 22	246.2 - 20	267.4 - 19	288.7 - 18	310.1 - 16	331.5 - 15
37	237.0 - 22	260.7 - 21	283.6 - 20	306.4 - 18	329.0 - 17	351.5 - 16
38	250.3 - 23	275.2 - 22	299.6 - 20	324.1 - 19	347.8 - 18	371.5 - 16
39	264.8 - 24	291.4 - 22	316.9 - 21	342.4 - 20	367.6 - 18	392.8 - 17
40	279.3 - 25	307.7 - 23	334.2 - 22	360.6 - 20	387.4 - 19	414.1 - 17

Table 16.--Gross volume (cubic feet, inside bark)
Form Class 79 Trees

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem					
	12	16	20	24	28	32
5	1.4	1.8	2.1	2.4	2.7	3.0
6	1.8	2.4	2.8	3.2	3.6	3.9
7	2.4	3.1	3.6	4.1	4.6	5.1
8	3.1	4.0	4.6	5.3	5.9	6.5
9	3.9	5.0	5.7	6.5	7.2	7.9
10	4.7	6.2	7.1	7.9	8.8	9.7

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs				
	1	1½	2	2½	3
10	6.2 - 8	8.5 - 7"	10.8 - 6	12.4 - 6"	14.1 - 5
11	7.6 - 9	10.4 - 8	13.2 - 7	15.3 - 7	17.4 - 6
12	8.9 - 9	12.2 - 9	15.6 - 8	18.2 - 7	20.7 - 7
13	10.5 - 10	14.4 - 9	18.4 - 9	21.5 - 8	24.6 - 7
14	12.1 - 11	16.7 - 10	21.3 - 9	24.9 - 9	28.5 - 8
15	13.9 - 12	19.2 - 11	24.4 - 10	28.6 - 9	32.8 - 9
16	15.7 - 13	21.6 - 12	27.6 - 11	32.4 - 10	37.2 - 9
17	17.8 - 13	24.6 - 12	31.4 - 11	36.9 - 11	42.4 - 10
18	19.9 - 14	27.6 - 13	35.2 - 12	41.4 - 11	47.6 - 11
19	22.2 - 15	30.8 - 14	39.4 - 13	46.4 - 12	53.4 - 11
20	24.6 - 16	34.2 - 15	43.7 - 14	51.5 - 13	59.3 - 12
21	27.4 - 17	38.0 - 15	48.6 - 14	57.3 - 14	66.0 - 13
22	30.2 - 17	41.8 - 16	53.5 - 15	63.1 - 14	72.7 - 14
23	33.2 - 18	46.0 - 17	58.8 - 16	69.5 - 15	80.2 - 14
24	36.3 - 19	50.2 - 18	64.2 - 17	76.0 - 16	87.7 - 15
25	39.4 - 20	54.6 - 19	69.7 - 17	82.4 - 16	95.2 - 16
26	42.6 - 20	58.9 - 19	75.2 - 18	89.0 - 17	102.7 - 16
27	46.2 - 21	63.9 - 20	81.6 - 19	96.6 - 18	111.6 - 17
28	49.8 - 22	68.8 - 21	87.9 - 20	104.2 - 19	120.4 - 18
29	53.7 - 23	74.2 - 22	94.7 - 20	112.2 - 19	129.8 - 18
30	57.6 - 24	79.6 - 22	101.5 - 21	120.3 - 20	139.1 - 19
31	61.8 - 24	85.3 - 23	108.8 - 22	129.1 - 21	149.4 - 20
32	66.0 - 25	91.1 - 24	116.2 - 23	138.0 - 22	159.8 - 21
33	70.7 - 26	97.4 - 25	124.2 - 23	147.6 - 22	170.9 - 21
34	75.4 - 27	103.8 - 25	132.3 - 24	157.2 - 23	182.0 - 22
35	80.2 - 28	110.4 - 26	140.5 - 25	166.9 - 24	193.3 - 23
36	84.9 - 28	116.8 - 27	148.7 - 26	176.6 - 25	204.6 - 23
37	90.2 - 29	124.0 - 28	157.8 - 26	187.6 - 25	217.4 - 24
38	95.6 - 30	131.2 - 29	166.9 - 27	198.6 - 26	230.3 - 25
39	101.0 - 31	138.7 - 29	176.4 - 28	209.8 - 27	243.2 - 26
40	106.3 - 32	146.0 - 30	185.8 - 29	221.0 - 28	256.2 - 27

Table 16.--Continued

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem						
	36	40	44	48	52	56	60
5	3.3	3.6	3.9	4.2	4.5	4.8	5.1
6	4.3	4.7	5.1	5.5	5.9	6.2	6.6
7	5.6	6.1	6.6	7.1	7.6	8.1	8.6
8	7.2	7.8	8.5	9.1	9.7	10.4	11.0
9	8.7	9.4	10.1	10.9	11.6	12.3	13.1
10	10.5	11.4	12.2	13.1	14.0	14.8	15.7

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs					
	3½	4	4½	5	5½	6
10						
11						
12	22.6 - 6"	24.4 - 5"				
13	26.9 - 7	29.2 - 6				
14	31.2 - 7	34.0 - 6				
15	36.1 - 8	39.4 - 7				
16	41.0 - 9	44.9 - 8				
17	46.8 - 9	51.3 - 8				
18	52.6 - 10	57.7 - 9				
19	59.1 - 11	64.8 - 10				
20	65.6 - 11	72.0 - 10	77.2 - 9"	82.5 - 8"		
21	73.2 - 12	80.3 - 11	86.4 - 10	92.4 - 9		
22	80.6 - 13	88.6 - 11	95.4 - 10	102.3 - 9		
23	88.8 - 13	97.4 - 12	105.2 - 11	113.1 - 10		
24	97.0 - 14	106.2 - 13	115.0 - 12	123.9 - 11		
25	105.5 - 14	115.8 - 13	125.4 - 12	135.0 - 11		
26	114.0 - 15	125.3 - 14	135.8 - 13	146.2 - 12		
27	123.8 - 16	136.0 - 15	147.5 - 13	159.0 - 12		
28	133.5 - 16	146.6 - 15	159.2 - 14	171.7 - 13	183.2 - 12	194.7 - 10"
29	143.9 - 17	158.0 - 16	171.8 - 15	185.6 - 14	198.6 - 12	211.6 - 11
30	154.2 - 18	169.4 - 16	184.4 - 15	199.5 - 14	214.0 - 13	228.4 - 12
31	165.9 - 18	182.4 - 17	198.3 - 16	214.2 - 15	230.0 - 14	245.9 - 12
32	177.6 - 19	195.5 - 18	212.2 - 17	229.0 - 15	246.2 - 14	263.4 - 13
33	190.0 - 20	209.2 - 19	227.2 - 17	245.1 - 16	263.8 - 15	282.6 - 14
34	202.4 - 21	222.8 - 19	242.0 - 18	261.2 - 17	281.4 - 15	301.7 - 14
35	215.0 - 21	236.7 - 20	257.2 - 19	277.8 - 17	298.8 - 16	319.9 - 15
36	227.6 - 22	250.6 - 21	272.4 - 19	294.3 - 18	316.2 - 17	338.1 - 15
37	241.8 - 23	266.2 - 21	289.8 - 20	313.4 - 19	336.6 - 17	359.8 - 16
38	256.0 - 24	281.8 - 22	307.1 - 21	332.4 - 19	356.9 - 18	381.4 - 17
39	270.8 - 24	298.3 - 23	324.6 - 21	350.8 - 20	376.9 - 19	403.0 - 17
40	285.5 - 25	314.8 - 24	342.0 - 22	369.3 - 21	396.9 - 19	424.5 - 18

Table 17.--Gross volume (cubic feet, inside bark)
Form Class 80 Trees

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem					
	12	16	20	24	28	32
5	1.4	1.8	2.1	2.4	2.7	3.1
6	1.9	2.4	2.8	3.2	3.6	4.0
7	2.5	3.2	3.7	4.2	4.7	5.2
8	3.2	4.2	4.8	5.5	6.1	6.7
9	4.0	5.2	6.0	6.7	7.5	8.2
10	4.8	6.3	7.2	8.1	9.0	9.9

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs				
	1	1½	2	2½	3
10	6.3 - 8	8.6 - 7	11.0 - 7	12.7 - 6	14.4 - 5
11	7.6 - 9	10.5 - 8	13.4 - 7	15.6 - 7	17.7 - 6
12	8.9 - 10	12.3 - 9	15.7 - 8	18.4 - 7	21.0 - 7
13	10.5 - 10	14.6 - 10	18.6 - 9	21.8 - 8	25.0 - 7
14	12.1 - 11	16.8 - 10	21.5 - 9	25.2 - 9	28.9 - 8
15	14.0 - 12	19.4 - 11	24.8 - 10	29.2 - 10	33.6 - 9
16	15.9 - 13	22.0 - 12	28.2 - 11	33.2 - 10	38.2 - 10
17	18.0 - 14	25.0 - 13	32.1 - 12	37.8 - 11	43.5 - 10
18	20.2 - 14	28.1 - 13	36.0 - 12	42.4 - 12	48.8 - 11
19	22.7 - 15	31.6 - 14	40.4 - 13	47.6 - 12	54.8 - 12
20	25.2 - 16	35.0 - 15	44.8 - 14	52.8 - 13	60.9 - 12
21	28.0 - 17	38.9 - 16	49.8 - 15	58.7 - 14	67.6 - 13
22	30.8 - 18	42.8 - 16	54.7 - 15	64.6 - 15	74.4 - 14
23	33.9 - 18	47.0 - 17	60.2 - 16	71.1 - 15	82.0 - 14
24	37.0 - 19	51.3 - 18	65.6 - 17	77.6 - 16	89.6 - 15
25	40.4 - 20	56.0 - 19	71.6 - 18	84.7 - 17	97.8 - 16
26	43.8 - 21	60.6 - 20	77.5 - 18	91.7 - 17	105.9 - 17
27	47.4 - 22	65.6 - 20	83.9 - 19	99.4 - 18	114.8 - 17
28	51.1 - 22	70.7 - 21	90.3 - 20	107.0 - 19	123.8 - 18
29	55.0 - 23	76.1 - 22	97.2 - 21	115.2 - 20	133.3 - 19
30	59.0 - 24	81.6 - 23	104.1 - 21	123.4 - 20	142.8 - 19
31	63.2 - 25	87.4 - 23	111.5 - 22	132.4 - 21	153.2 - 20
32	67.4 - 26	93.2 - 24	118.9 - 23	141.3 - 22	163.7 - 21
33	72.0 - 26	99.4 - 25	126.8 - 24	150.8 - 23	174.7 - 22
34	76.5 - 27	105.6 - 26	134.8 - 24	160.2 - 23	185.7 - 22
35	81.6 - 28	112.6 - 27	143.6 - 25	170.7 - 24	197.8 - 23
36	86.6 - 29	119.4 - 27	152.3 - 26	181.1 - 25	209.9 - 24
37	91.7 - 30	126.4 - 28	161.2 - 27	191.9 - 26	222.6 - 25
38	96.8 - 30	133.4 - 29	170.1 - 27	202.8 - 26	235.4 - 25
39	102.2 - 31	140.9 - 30	179.6 - 28	214.0 - 27	248.4 - 26
40	107.5 - 32	148.3 - 31	189.1 - 29	225.3 - 28	261.5 - 27

Table 17.--Continued

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem						
	36	40	44	48	52	56	60
5	3.4	3.7	4.0	4.3	4.6	5.0	5.3
6	4.4	4.8	5.2	5.6	6.0	6.4	6.8
7	5.7	6.2	6.7	7.2	7.7	8.2	8.7
8	7.4	8.0	8.7	9.3	9.9	10.6	11.2
9	9.0	9.8	10.5	11.3	12.0	12.8	13.6
10	10.8	11.7	12.5	13.4	14.3	15.2	16.1

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs					
	3½	4	4½	5	5½	6
10						
11						
12	22.9 - 6"	24.8 - 5"				
13	27.3 - 7	29.6 - 6				
14	31.6 - 7	34.4 - 6				
15	37.0 - 8	40.3 - 7				
16	42.2 - 9	46.2 - 8				
17	48.2 - 9	52.8 - 9				
18	54.0 - 10	59.3 - 9				
19	60.7 - 11	66.6 - 10				
20	67.4 - 11	74.0 - 10	79.4 - 9"	84.9 - 8"		
21	75.0 - 12	82.4 - 11	88.6 - 10	94.8 - 9		
22	82.6 - 13	90.8 - 12	97.8 - 11	104.8 - 10		
23	90.9 - 13	99.8 - 12	107.8 - 11	115.8 - 10		
24	99.2 - 14	108.7 - 13	117.8 - 12	126.8 - 11		
25	108.4 - 15	119.0 - 14	129.0 - 12	138.9 - 11		
26	117.6 - 15	129.3 - 14	140.2 - 13	151.0 - 12		
27	127.4 - 16	140.1 - 15	152.0 - 14	164.0 - 13		
28	137.4 - 17	150.9 - 16	163.9 - 14	176.9 - 13	188.8 - 12"	200.7 - 10"
29	147.8 - 17	162.4 - 16	176.7 - 15	191.0 - 14	204.4 - 13	217.8 - 11
30	158.4 - 18	174.0 - 17	189.6 - 16	205.2 - 15	220.1 - 13	235.0 - 12
31	170.2 - 19	187.2 - 18	203.6 - 16	220.0 - 15	236.3 - 14	252.6 - 13
32	182.0 - 20	200.4 - 18	217.6 - 17	234.9 - 16	252.6 - 14	270.3 - 13
33	194.4 - 20	214.0 - 19	232.5 - 18	251.0 - 16	270.3 - 15	289.6 - 14
34	206.6 - 21	227.6 - 20	247.4 - 18	267.1 - 17	288.0 - 16	308.8 - 15
35	220.2 - 22	242.6 - 20	263.8 - 19	285.0 - 18	306.8 - 16	328.5 - 15
36	233.8 - 22	257.6 - 21	280.2 - 20	302.8 - 18	325.5 - 17	348.2 - 16
37	247.8 - 23	273.1 - 22	297.4 - 20	321.8 - 19	345.8 - 18	369.8 - 16
38	262.0 - 24	288.6 - 22	314.8 - 21	340.9 - 20	366.2 - 18	391.5 - 17
39	276.8 - 25	305.2 - 23	332.4 - 22	359.6 - 20	386.4 - 19	413.3 - 18
40	291.7 - 25	321.9 - 24	350.0 - 23	378.2 - 21	406.6 - 20	435.1 - 18

Table 18.--Gross volume (cubic feet, inside bark)
Form Class 81 Trees

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem					
	12	16	20	24	28	32
5	1.4	1.8	2.1	2.4	2.7	3.1
6	1.9	2.4	2.8	3.2	3.6	4.0
7	2.6	3.4	3.9	4.4	5.0	5.5
8	3.3	4.3	5.0	5.6	6.3	6.9
9	4.1	5.3	6.1	6.9	7.7	8.4
10	5.0	6.4	7.3	8.2	9.2	10.1

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs				
	1	1½	2	2½	3
10	6.4 - 8"	8.8 - 7"	11.2 - 7"	13.0 - 6"	14.7 - 5"
11	7.8 - 9	10.7 - 8	13.6 - 7	15.8 - 7	18.0 - 6
12	9.1 - 10	12.6 - 9	16.1 - 8	18.8 - 7	21.4 - 7
13	10.8 - 10	14.9 - 10	19.0 - 9	22.2 - 8	25.4 - 8
14	12.4 - 11	17.2 - 10	22.0 - 10	25.8 - 9	29.5 - 8
15	14.4 - 12	20.0 - 11	25.6 - 10	30.0 - 10	34.5 - 9
16	16.4 - 13	22.8 - 12	29.2 - 11	34.4 - 10	39.5 - 10
17	18.6 - 14	25.8 - 13	33.0 - 12	38.9 - 11	44.8 - 10
18	20.7 - 15	28.8 - 14	36.9 - 13	43.6 - 12	50.2 - 11
19	23.2 - 15	32.3 - 14	41.4 - 13	48.9 - 13	56.4 - 12
20	25.8 - 16	35.8 - 15	45.9 - 14	54.2 - 13	62.5 - 13
21	28.6 - 17	39.8 - 16	50.9 - 15	60.2 - 14	69.4 - 13
22	31.5 - 18	43.7 - 17	55.9 - 16	66.0 - 15	76.2 - 14
23	34.4 - 19	47.8 - 17	61.2 - 16	72.4 - 16	83.7 - 15
24	37.4 - 19	52.0 - 18	66.6 - 17	78.9 - 16	91.2 - 15
25	41.0 - 20	57.0 - 19	73.0 - 18	86.5 - 17	100.0 - 16
26	44.6 - 21	62.0 - 20	79.3 - 19	94.0 - 18	108.7 - 17
27	48.3 - 22	67.0 - 21	85.8 - 19	101.8 - 18	117.8 - 18
28	52.0 - 23	72.2 - 21	92.3 - 20	109.6 - 19	126.9 - 18
29	56.0 - 23	77.6 - 22	99.2 - 21	117.8 - 20	136.4 - 19
30	59.9 - 24	83.0 - 23	106.2 - 22	126.1 - 21	146.0 - 20
31	64.2 - 25	89.0 - 24	113.7 - 22	135.2 - 21	156.6 - 20
32	68.4 - 26	94.8 - 25	121.2 - 23	144.2 - 22	167.1 - 21
33	73.0 - 27	101.1 - 25	129.2 - 24	153.7 - 23	178.2 - 22
34	77.5 - 27	107.3 - 26	137.1 - 25	163.2 - 24	189.3 - 23
35	82.6 - 28	114.4 - 27	146.2 - 26	174.1 - 25	202.0 - 23
36	87.7 - 29	121.5 - 28	155.3 - 26	185.0 - 25	214.8 - 24
37	93.1 - 30	128.8 - 29	164.6 - 27	196.2 - 26	227.9 - 25
38	98.5 - 31	136.2 - 29	173.9 - 28	207.4 - 27	241.0 - 26
39	104.0 - 32	143.8 - 30	183.6 - 29	219.0 - 28	254.3 - 27
40	109.4 - 32	151.3 - 31	193.2 - 30	230.4 - 28	267.6 - 27

Table 18.--Continued

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem						
	36	40	44	48	52	56	60
5	3.4	3.7	4.0	4.3	4.6	5.0	5.3
6	4.4	4.8	5.2	5.6	6.0	6.4	6.8
7	6.0	6.5	7.1	7.6	8.1	8.6	9.2
8	7.6	8.3	8.9	9.6	10.2	10.9	11.6
9	9.2	10.0	10.8	11.6	12.4	13.1	13.9
10	11.0	11.9	12.8	13.8	14.7	15.6	16.5

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs					
	3½	4	4½	5	5½	6
10						
11						
12	23.4 - 6"	25.4 - 5"				
13	27.8 - 7	30.3 - 6				
14	32.4 - 7	35.2 - 7				
15	38.0 - 8	41.6 - 7				
16	43.7 - 9	47.9 - 8				
17	49.6 - 10	54.4 - 9				
18	55.6 - 10	61.0 - 9				
19	62.4 - 11	68.5 - 10				
20	69.2 - 12	76.0 - 11	81.6 - 9"	87.3 - 8"		
21	77.0 - 12	84.6 - 11	91.0 - 10	97.4 - 9		
22	84.6 - 13	93.1 - 12	100.4 - 11	107.6 - 10		
23	92.8 - 14	102.0 - 12	110.2 - 11	118.5 - 10		
24	101.0 - 14	110.8 - 13	120.1 - 12	129.4 - 11		
25	111.0 - 15	121.9 - 14	132.3 - 13	142.4 - 12		
26	120.8 - 16	133.0 - 15	144.2 - 13	155.5 - 12		
27	130.9 - 16	144.0 - 15	156.3 - 14	168.6 - 13		
28	140.9 - 17	154.9 - 16	168.3 - 15	181.7 - 14	194.0 - 12"	206.4 - 11"
29	151.5 - 18	166.6 - 16	181.3 - 15	196.0 - 14	209.9 - 13	223.8 - 11
30	162.2 - 18	178.3 - 17	194.3 - 16	210.3 - 15	225.7 - 14	241.1 - 12
31	174.1 - 19	191.6 - 18	208.5 - 17	225.4 - 15	242.2 - 14	259.0 - 13
32	186.0 - 20	205.0 - 19	222.8 - 17	240.5 - 16	258.7 - 15	276.9 - 14
33	198.4 - 21	218.7 - 19	237.8 - 18	256.8 - 17	276.6 - 15	296.3 - 14
34	210.8 - 21	232.4 - 20	252.7 - 19	273.0 - 17	294.4 - 16	315.7 - 15
35	225.1 - 22	248.2 - 21	270.1 - 19	292.0 - 18	314.4 - 17	336.8 - 16
36	239.4 - 23	264.1 - 21	287.5 - 20	310.9 - 19	334.4 - 17	357.8 - 16
37	254.0 - 24	280.0 - 22	305.2 - 21	330.4 - 20	355.2 - 18	380.0 - 17
38	268.5 - 24	296.0 - 23	323.0 - 22	350.0 - 20	376.1 - 19	402.2 - 17
39	283.6 - 25	312.9 - 24	341.0 - 22	369.0 - 21	396.7 - 19	424.4 - 18
40	298.7 - 26	329.8 - 24	358.8 - 23	387.9 - 21	417.2 - 20	446.5 - 18

Table 19.--Gross volume (cubic feet, inside bark)
Form Class 82 Trees

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem					
	12	16	20	24	28	32
5	1.4	1.8	2.1	2.5	2.8	3.1
6	1.9	2.4	2.8	3.2	3.7	4.1
7	2.6	3.4	3.9	4.5	5.0	5.6
8	3.4	4.4	5.1	5.8	6.5	7.1
9	4.2	5.4	6.2	7.0	7.8	8.6
10	5.1	6.6	7.6	8.5	9.5	10.4

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs				
	1	1½	2	2½	3
10	6.6 - 8"	9.1 - 7"	11.6 - 7"	13.4 - 6"	15.2 - 6"
11	8.0 - 9	11.0 - 8	14.0 - 7	16.3 - 7	18.6 - 6
12	9.3 - 10	12.8 - 9	16.4 - 8	19.2 - 8	21.9 - 7
13	11.0 - 11	15.3 - 10	19.6 - 9	22.9 - 8	26.2 - 8
14	12.8 - 11	17.8 - 11	22.8 - 10	26.7 - 9	30.6 - 8
15	14.7 - 12	20.4 - 11	26.2 - 10	30.8 - 10	35.4 - 9
16	16.6 - 13	23.1 - 12	29.6 - 11	34.8 - 11	40.1 - 10
17	18.9 - 14	26.4 - 13	33.8 - 12	39.8 - 11	45.8 - 11
18	21.2 - 15	29.6 - 14	37.9 - 13	44.8 - 12	51.6 - 11
19	23.6 - 16	33.0 - 15	42.4 - 14	50.1 - 13	57.8 - 12
20	26.1 - 16	36.4 - 15	46.8 - 14	55.4 - 14	63.9 - 13
21	28.8 - 17	40.2 - 16	51.6 - 15	61.1 - 14	70.6 - 13
22	31.5 - 18	44.0 - 17	56.5 - 16	66.9 - 15	77.3 - 14
23	34.8 - 19	48.6 - 18	62.4 - 17	74.0 - 16	85.6 - 15
24	38.1 - 20	53.2 - 19	68.2 - 17	81.0 - 17	93.8 - 16
25	41.6 - 20	58.0 - 19	74.3 - 18	88.2 - 17	102.1 - 16
26	45.0 - 21	62.7 - 20	80.4 - 19	95.4 - 18	110.4 - 17
27	48.9 - 22	68.1 - 21	87.3 - 20	103.7 - 19	120.1 - 18
28	52.8 - 23	73.5 - 22	94.2 - 20	112.0 - 20	129.8 - 19
29	56.8 - 24	79.0 - 22	101.2 - 21	120.4 - 20	139.5 - 19
30	60.8 - 25	84.6 - 23	108.3 - 22	128.8 - 21	149.2 - 20
31	65.1 - 25	90.4 - 24	115.8 - 23	137.8 - 22	159.9 - 21
32	69.4 - 26	96.4 - 25	123.4 - 23	147.0 - 22	170.6 - 21
33	74.2 - 27	103.1 - 26	132.0 - 24	157.2 - 23	182.5 - 22
34	79.1 - 28	109.8 - 26	140.6 - 25	167.5 - 24	194.4 - 23
35	84.0 - 29	116.6 - 27	149.2 - 26	177.9 - 25	206.6 - 24
36	88.8 - 29	123.4 - 28	157.9 - 27	188.3 - 26	218.7 - 25
37	94.2 - 30	130.8 - 29	167.3 - 27	200.0 - 26	232.5 - 25
38	99.7 - 31	138.4 - 30	177.1 - 28	211.7 - 27	246.3 - 26
39	105.2 - 32	146.0 - 31	186.8 - 29	223.2 - 28	259.6 - 27
40	110.6 - 33	153.6 - 31	196.6 - 30	234.8 - 29	273.0 - 28

Table 19.--Continued

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem						
	36	40	44	48	52	56	60
5	3.5	3.8	4.1	4.5	4.8	5.1	5.5
6	4.5	4.9	5.4	5.8	6.2	6.6	7.1
7	6.1	6.7	7.2	7.8	8.3	8.8	9.4
8	7.8	8.5	9.2	9.9	10.6	11.2	11.9
9	9.5	10.3	11.1	11.9	12.7	13.5	14.3
10	11.4	12.3	13.3	14.2	15.2	16.1	17.1

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs					
	3½	4	4½	5	5½	6
10						
11						
12	24.0 - 6"	26.0 - 5"				
13	28.8 - 7	31.3 - 6				
14	33.6 - 8	36.6 - 7				
15	39.0 - 8	42.6 - 7				
16	44.4 - 9	48.6 - 8				
17	50.8 - 10	55.7 - 9				
18	57.2 - 10	62.8 - 10				
19	64.0 - 11	70.3 - 10				
20	70.8 - 12	77.8 - 11	83.6 - 10"	89.4 - 9"		
21	78.4 - 12	86.2 - 11	92.8 - 10	99.5 - 9		
22	86.0 - 13	94.7 - 12	102.2 - 11	109.6 - 10		
23	95.0 - 14	104.4 - 13	113.0 - 12	121.6 - 11		
24	104.0 - 15	114.1 - 13	123.8 - 12	133.5 - 11		
25	113.4 - 15	124.7 - 14	135.4 - 13	146.0 - 12		
26	122.8 - 16	135.3 - 15	146.8 - 14	158.4 - 13		
27	133.6 - 17	147.0 - 15	159.8 - 14	172.5 - 13		
28	144.3 - 17	158.8 - 16	172.7 - 15	186.6 - 14	199.4 - 12"	212.1 - 11"
29	155.0 - 18	170.6 - 17	185.8 - 16	201.0 - 15	215.4 - 13	229.7 - 12
30	165.8 - 19	182.5 - 17	199.0 - 16	215.5 - 15	231.4 - 14	247.3 - 12
31	178.0 - 19	196.0 - 18	213.4 - 17	230.8 - 16	248.1 - 14	265.4 - 13
32	190.1 - 20	209.6 - 19	227.9 - 18	246.2 - 16	264.9 - 15	283.6 - 14
33	203.4 - 21	224.4 - 20	244.0 - 18	263.7 - 17	284.2 - 16	304.6 - 15
34	216.8 - 22	239.1 - 20	260.2 - 19	281.2 - 18	303.4 - 16	325.5 - 15
35	230.4 - 22	254.2 - 21	276.7 - 20	299.2 - 18	322.3 - 17	345.4 - 16
36	244.0 - 23	269.2 - 22	293.2 - 20	317.2 - 19	341.3 - 18	365.4 - 16
37	259.3 - 24	286.1 - 22	312.0 - 21	338.0 - 20	363.5 - 19	389.0 - 17
38	274.6 - 25	303.0 - 23	330.8 - 22	358.7 - 21	385.6 - 19	412.6 - 18
39	289.8 - 25	320.0 - 24	348.9 - 23	377.8 - 21	406.4 - 20	435.0 - 18
40	305.0 - 26	337.1 - 25	367.0 - 23	397.0 - 22	427.2 - 20	457.4 - 19

Table 20.--Gross volume (cubic feet, inside bark)
Form Class 83 Trees

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem					
	12	16	20	24	28	32
5	1.4	1.8	2.1	2.5	2.8	3.2
6	2.0	2.5	2.9	3.4	3.8	4.3
7	2.6	3.4	4.0	4.5	5.1	5.7
8	3.4	4.4	5.1	5.8	6.5	7.2
9	4.2	5.4	6.2	7.1	7.9	8.8
10	5.1	6.6	7.6	8.5	9.5	10.4

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs				
	1	1½	2	2½	3
10	6.6 - 8"	9.2 - 8"	11.7 - 7"	13.6 - 6"	15.4 - 6"
11	8.1 - 9	11.2 - 8	14.4 - 8	16.8 - 7	19.1 - 6
12	9.6 - 10	13.3 - 9	17.0 - 8	19.9 - 8	22.8 - 7
13	11.3 - 11	15.7 - 10	20.1 - 9	23.6 - 9	27.0 - 8
14	13.0 - 12	18.1 - 11	23.2 - 10	27.2 - 9	31.2 - 9
15	15.0 - 12	20.9 - 11	26.8 - 11	31.6 - 10	36.3 - 9
16	17.1 - 13	23.8 - 12	30.5 - 11	36.0 - 11	41.4 - 10
17	19.3 - 14	26.9 - 13	34.5 - 12	40.7 - 11	46.9 - 11
18	21.5 - 15	30.0 - 14	38.5 - 13	45.4 - 12	52.4 - 11
19	24.1 - 16	33.6 - 15	43.2 - 14	51.1 - 13	59.0 - 12
20	26.7 - 17	37.3 - 16	47.9 - 14	56.7 - 14	65.5 - 13
21	29.6 - 17	41.4 - 16	53.2 - 15	63.0 - 15	72.6 - 14
22	32.5 - 18	45.4 - 17	58.4 - 16	69.2 - 15	80.1 - 14
23	35.6 - 19	49.8 - 18	64.0 - 17	76.0 - 16	87.9 - 15
24	38.8 - 20	54.2 - 19	69.6 - 18	82.6 - 17	95.7 - 16
25	42.3 - 21	59.1 - 20	75.9 - 18	90.2 - 17	104.4 - 17
26	45.8 - 22	64.0 - 20	82.2 - 19	97.7 - 18	113.2 - 17
27	49.5 - 22	69.2 - 21	88.8 - 20	105.6 - 19	122.4 - 18
28	53.2 - 23	74.3 - 22	95.4 - 21	113.6 - 20	131.7 - 19
29	57.4 - 24	80.2 - 23	103.0 - 21	122.6 - 21	142.1 - 20
30	61.7 - 25	86.1 - 24	110.5 - 22	131.5 - 21	152.5 - 20
31	66.3 - 26	92.4 - 24	118.6 - 23	141.3 - 22	164.0 - 21
32	70.9 - 27	98.8 - 25	126.7 - 24	151.1 - 23	175.5 - 22
33	75.5 - 27	105.2 - 26	134.8 - 25	160.8 - 24	186.8 - 23
34	80.1 - 28	111.5 - 27	142.9 - 25	170.5 - 24	198.1 - 23
35	85.3 - 29	118.8 - 28	152.2 - 26	181.7 - 25	211.2 - 24
36	90.5 - 30	126.0 - 28	161.6 - 27	192.9 - 26	224.2 - 25
37	95.7 - 31	133.2 - 29	170.8 - 28	204.1 - 27	237.4 - 26
38	100.9 - 31	140.4 - 30	179.9 - 29	215.2 - 28	250.5 - 27
39	106.7 - 32	148.5 - 31	190.3 - 29	227.6 - 28	264.8 - 27
40	112.5 - 33	156.6 - 32	200.7 - 30	239.9 - 29	279.1 - 28

Table 20.--Continued

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem						
	36	40	44	48	52	56	60
5	3.5	3.9	4.2	4.6	4.9	5.3	5.6
6	4.7	5.1	5.6	6.0	6.5	6.9	7.3
7	6.2	6.8	7.4	7.9	8.5	9.1	9.6
8	7.9	8.6	9.4	10.1	10.8	11.5	12.2
9	9.6	10.4	11.3	12.1	13.0	13.8	14.6
10	11.4	12.3	13.3	14.2	15.2	16.1	17.1

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs					
	3½	4	4½	5	5½	6
10						
11						
12	25.0 - 6"	27.2 - 6"				
13	29.6 - 7	32.2 - 6				
14	34.2 - 8	37.3 - 7				
15	40.0 - 8	43.8 - 8				
16	45.8 - 9	50.3 - 8				
17	52.0 - 10	57.0 - 9				
18	58.1 - 11	63.8 - 10				
19	65.4 - 11	71.8 - 10				
20	72.6 - 12	79.8 - 11	85.8 - 10"	91.9 - 9"		
21	80.9 - 13	89.0 - 12	95.9 - 11	102.8 - 10		
22	89.1 - 13	98.1 - 12	105.9 - 11	113.7 - 10		
23	97.6 - 14	107.4 - 13	116.2 - 12	125.1 - 11		
24	106.2 - 15	116.6 - 14	126.6 - 13	136.5 - 11		
25	116.1 - 15	127.8 - 14	138.8 - 13	149.7 - 12		
26	126.1 - 16	139.0 - 15	151.0 - 14	162.9 - 13		
27	136.3 - 17	150.2 - 16	163.2 - 15	176.3 - 14		
28	146.5 - 18	161.3 - 16	175.5 - 15	189.7 - 14	202.7 - 13"	215.7 - 11
29	158.0 - 18	174.0 - 17	189.6 - 16	205.3 - 15	220.0 - 13	234.6 - 12
30	169.6 - 19	186.8 - 18	203.8 - 17	220.9 - 15	237.2 - 14	253.5 - 13
31	182.7 - 20	201.4 - 18	219.4 - 17	237.4 - 16	255.3 - 15	273.2 - 14
32	195.7 - 21	215.9 - 19	234.9 - 18	253.9 - 17	273.4 - 15	292.8 - 14
33	208.4 - 21	230.0 - 20	250.3 - 19	270.6 - 17	291.6 - 16	312.7 - 15
34	221.0 - 22	244.0 - 21	265.6 - 19	287.2 - 18	309.9 - 17	332.6 - 16
35	235.7 - 23	260.2 - 21	283.4 - 20	306.6 - 19	330.4 - 17	354.2 - 16
36	250.4 - 24	276.5 - 22	301.3 - 21	326.1 - 19	351.0 - 18	375.8 - 17
37	265.0 - 24	292.6 - 23	319.2 - 21	345.8 - 20	372.0 - 19	398.2 - 17
38	279.6 - 25	308.6 - 24	337.0 - 22	365.5 - 21	393.1 - 20	420.7 - 18
39	295.8 - 26	326.9 - 24	356.6 - 23	386.2 - 22	415.6 - 20	444.9 - 19
40	312.2 - 27	345.2 - 25	376.0 - 24	406.9 - 22	438.0 - 21	469.1 - 19

Table 21.--Gross volume (cubic feet, inside bark)
Form Class 84 Trees

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem					
	12	16	20	24	28	32
5	1.4	1.8	2.1	2.5	2.8	3.2
6	2.0	2.5	2.9	3.4	3.8	4.3
7	2.7	3.5	4.1	4.6	5.2	5.8
8	3.4	4.4	5.1	5.8	6.5	7.2
9	4.3	5.6	6.4	7.3	8.1	9.0
10	5.2	6.8	7.8	8.8	9.7	10.7

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs				
	1	1½	2	2½	3
10	6.8 - 8	9.4 - 8"	12.0 - 7	14.0 - 6"	15.9 - 6"
11	8.3 - 9	11.5 - 8	14.7 - 8	17.2 - 7	19.6 - 7
12	9.8 - 10	13.6 - 9	17.4 - 8	20.4 - 8	23.3 - 7
13	11.6 - 11	16.1 - 10	20.6 - 9	24.2 - 9	27.8 - 8
14	13.4 - 12	18.6 - 11	23.9 - 10	28.1 - 9	32.3 - 9
15	15.4 - 13	21.4 - 12	27.4 - 11	32.3 - 10	37.2 - 9
16	17.3 - 13	24.1 - 12	30.9 - 11	36.4 - 11	42.0 - 10
17	19.7 - 14	27.4 - 13	35.2 - 12	41.6 - 12	48.0 - 11
18	22.1 - 15	30.8 - 14	39.5 - 13	46.7 - 12	53.9 - 12
19	24.7 - 16	34.4 - 15	44.2 - 14	52.4 - 13	60.5 - 12
20	27.3 - 17	38.2 - 16	49.0 - 15	58.0 - 14	67.1 - 13
21	30.2 - 18	42.3 - 17	54.4 - 15	64.4 - 15	74.5 - 14
22	33.2 - 18	46.4 - 17	59.7 - 16	70.8 - 15	81.9 - 15
23	36.6 - 19	51.2 - 18	65.8 - 17	78.1 - 16	90.4 - 15
24	40.0 - 20	55.9 - 19	71.8 - 18	85.3 - 17	98.8 - 16
25	43.3 - 21	60.6 - 20	77.8 - 19	92.4 - 18	107.1 - 17
26	46.6 - 22	65.2 - 21	83.8 - 19	99.6 - 18	115.4 - 18
27	50.6 - 23	70.7 - 21	90.8 - 20	108.0 - 19	125.3 - 18
28	54.5 - 23	76.2 - 22	97.8 - 21	116.5 - 20	135.2 - 19
29	58.6 - 24	81.9 - 23	105.2 - 22	125.4 - 21	145.6 - 20
30	62.7 - 25	87.7 - 24	112.7 - 23	134.3 - 22	155.9 - 21
31	67.3 - 26	94.0 - 25	120.8 - 23	144.2 - 22	167.5 - 21
32	71.9 - 27	100.4 - 26	129.0 - 24	154.0 - 23	179.1 - 22
33	76.8 - 28	107.2 - 26	137.7 - 25	164.4 - 24	191.2 - 23
34	81.7 - 29	114.0 - 27	146.4 - 26	174.9 - 25	203.4 - 24
35	86.6 - 29	121.0 - 28	155.3 - 27	185.6 - 26	215.8 - 25
36	91.6 - 30	127.9 - 29	164.2 - 27	196.2 - 26	228.2 - 25
37	97.2 - 31	135.6 - 30	174.0 - 28	208.2 - 27	242.3 - 26
38	102.7 - 32	143.2 - 30	183.8 - 29	220.1 - 28	256.4 - 27
39	108.6 - 33	151.4 - 31	194.3 - 30	232.6 - 29	270.9 - 28
40	114.4 - 34	159.6 - 32	204.8 - 31	245.1 - 30	285.4 - 29

Table 21.--Continued

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem						
	36	40	44	48	52	56	60
5	3.5	3.9	4.2	4.6	4.9	5.3	5.6
6	4.7	5.1	5.6	6.0	6.5	6.9	7.3
7	6.3	6.9	7.5	8.0	8.6	9.2	9.7
8	7.9	8.6	9.4	10.1	10.8	11.5	12.2
9	9.8	10.6	11.5	12.3	13.2	14.0	14.8
10	11.7	12.7	13.7	14.6	15.6	16.6	17.6

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs					
	3½	4	4½	5	5½	6
10						
11						
12	25.6 - 6"	27.8 - 6"				
13	30.5 - 7	33.2 - 6				
14	35.5 - 8	38.7 - 7				
15	41.0 - 9	44.9 - 8				
16	46.6 - 9	51.1 - 8				
17	53.2 - 10	58.4 - 9				
18	59.8 - 11	65.7 - 10				
19	67.2 - 11	73.8 - 11				
20	74.5 - 12	81.9 - 11	88.1 - 10	94.3 - 9"		
21	82.8 - 13	91.2 - 12	98.3 - 11	105.4 - 10		
22	91.2 - 14	100.5 - 13	108.5 - 12	116.5 - 10		
23	100.4 - 14	110.5 - 13	119.6 - 12	128.8 - 11		
24	109.6 - 15	120.5 - 14	130.8 - 13	141.2 - 12		
25	119.2 - 16	131.2 - 15	142.4 - 13	153.7 - 12		
26	128.6 - 16	141.8 - 15	154.0 - 14	166.2 - 13		
27	139.6 - 17	153.8 - 16	167.2 - 15	180.6 - 14		
28	150.5 - 18	165.8 - 17	180.4 - 16	195.1 - 14	208.6 - 13"	222.1 - 11"
29	162.0 - 19	178.5 - 17	194.6 - 16	210.7 - 15	225.8 - 14	241.0 - 12
30	173.6 - 19	191.2 - 18	208.8 - 17	226.3 - 16	243.2 - 14	260.0 - 13
31	186.7 - 20	205.9 - 19	224.4 - 18	243.0 - 16	261.4 - 15	279.8 - 14
32	199.8 - 21	220.6 - 20	240.2 - 18	259.7 - 17	279.7 - 16	299.7 - 15
33	213.4 - 22	235.7 - 20	256.6 - 19	277.6 - 18	299.4 - 16	321.2 - 15
34	227.1 - 22	250.8 - 21	273.2 - 20	295.6 - 18	319.1 - 17	342.6 - 16
35	241.0 - 23	266.3 - 22	290.2 - 20	314.1 - 19	338.6 - 18	363.1 - 17
36	255.0 - 24	281.8 - 22	307.2 - 21	332.6 - 20	358.1 - 18	383.6 - 17
37	270.6 - 25	299.0 - 23	326.4 - 22	353.8 - 21	380.8 - 19	407.8 - 18
38	286.4 - 26	316.3 - 24	345.6 - 23	375.0 - 21	403.5 - 20	432.0 - 18
39	302.8 - 26	334.8 - 25	365.4 - 23	395.9 - 22	426.2 - 21	456.5 - 19
40	319.4 - 27	353.3 - 26	385.0 - 24	416.8 - 23	448.9 - 21	481.0 - 20

Table 22.--Gross volume (cubic feet, inside bark)
Form Class 85 Trees

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem					
	12	16	20	24	28	32
5	1.4	1.8	2.2	2.5	2.9	3.3
6	2.1	2.6	3.1	3.5	4.0	4.4
7	2.8	3.6	4.2	4.8	5.4	6.0
8	3.5	4.5	5.2	6.0	6.7	7.4
9	4.3	5.6	6.5	7.3	8.2	9.1
10	5.3	6.9	7.9	8.9	9.9	10.9

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs				
	1	1½	2	2½	3
10	6.9 - 8"	9.6 - 8"	12.3 - 7"	14.2 - 6"	16.2 - 6"
11	8.4 - 9	11.7 - 9	15.0 - 8	17.5 - 7	20.0 - 7
12	10.0 - 10	13.9 - 9	17.8 - 9	20.8 - 8	23.8 - 7
13	11.8 - 11	16.4 - 10	21.0 - 9	24.6 - 9	28.3 - 8
14	13.6 - 12	19.0 - 11	24.3 - 10	28.6 - 10	32.8 - 9
15	15.6 - 13	21.8 - 12	28.0 - 11	33.0 - 10	38.0 - 10
16	17.6 - 14	24.6 - 13	31.6 - 12	37.4 - 11	43.2 - 10
17	20.0 - 14	28.0 - 13	35.9 - 12	42.6 - 12	49.2 - 11
18	22.3 - 15	31.2 - 14	40.2 - 13	47.6 - 13	55.1 - 12
19	25.0 - 16	35.0 - 15	45.0 - 14	53.4 - 13	61.8 - 13
20	27.6 - 17	38.8 - 16	49.9 - 15	59.2 - 14	68.5 - 13
21	30.8 - 18	43.1 - 17	55.4 - 16	65.8 - 15	76.2 - 14
22	33.9 - 19	47.4 - 18	61.0 - 16	72.4 - 16	83.8 - 15
23	37.3 - 20	52.2 - 18	67.1 - 17	79.7 - 16	92.3 - 16
24	40.7 - 20	57.0 - 19	73.2 - 18	87.0 - 17	100.8 - 16
25	44.2 - 21	61.9 - 20	79.6 - 19	94.7 - 18	109.8 - 17
26	47.8 - 22	66.9 - 21	86.0 - 20	102.4 - 19	118.7 - 18
27	51.6 - 23	72.3 - 22	93.0 - 20	110.8 - 20	128.6 - 19
28	55.4 - 24	77.6 - 23	99.9 - 21	119.2 - 20	138.4 - 19
29	59.8 - 25	83.7 - 23	107.6 - 22	128.3 - 21	149.0 - 20
30	64.1 - 25	89.8 - 24	115.4 - 23	137.6 - 22	159.7 - 21
31	68.5 - 26	96.0 - 25	123.4 - 24	147.3 - 23	171.2 - 22
32	72.9 - 27	102.2 - 26	131.4 - 24	157.0 - 23	182.7 - 22
33	77.8 - 28	109.0 - 27	140.2 - 25	167.6 - 24	195.0 - 23
34	82.8 - 29	115.9 - 27	149.0 - 26	178.2 - 25	207.3 - 24
35	88.0 - 30	123.2 - 28	158.4 - 27	189.5 - 26	220.6 - 25
36	93.3 - 31	130.6 - 29	167.9 - 28	200.9 - 27	233.9 - 26
37	98.9 - 31	138.4 - 30	177.8 - 29	213.0 - 28	248.2 - 27
38	104.5 - 32	146.1 - 31	187.7 - 29	225.0 - 28	262.4 - 27
39	110.4 - 33	154.4 - 32	198.3 - 30	237.6 - 29	277.0 - 28
40	116.3 - 34	162.6 - 33	208.9 - 31	250.3 - 30	291.7 - 29

Table 22.--Continued

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem						
	36	40	44	48	52	56	60
5	3.6	4.0	4.4	4.7	5.1	5.5	5.8
6	4.9	5.4	5.8	6.3	6.7	7.2	7.7
7	6.5	7.1	7.7	8.3	8.9	9.5	10.1
8	8.2	8.9	9.6	10.4	11.1	11.8	12.6
9	9.9	10.8	11.6	12.5	13.4	14.2	15.1
10	11.9	12.9	14.0	15.0	16.0	17.0	18.0

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs					
	3½	4	4½	5	5½	6
10						
11						
12	26.1 - 7"	28.4 - 6"				
13	31.1 - 7	33.9 - 6				
14	36.1 - 8	39.4 - 7				
15	42.0 - 9	46.0 - 8				
16	47.9 - 10	52.6 - 9				
17	54.6 - 10	60.0 - 9				
18	61.2 - 11	67.3 - 10				
19	68.6 - 12	75.5 - 11				
20	76.1 - 12	83.7 - 11	90.2 - 10"	96.6 - 9"		
21	84.8 - 13	93.3 - 12	100.6 - 11	108.0 - 10		
22	93.4 - 14	102.9 - 13	111.2 - 12	119.4 - 11		
23	102.6 - 14	113.0 - 13	122.4 - 12	131.8 - 11		
24	111.9 - 15	123.0 - 14	133.6 - 13	144.3 - 12		
25	122.2 - 16	134.5 - 15	146.2 - 14	157.8 - 13		
26	132.4 - 17	146.0 - 16	158.6 - 14	171.3 - 13		
27	143.3 - 17	158.0 - 16	171.9 - 15	185.8 - 14		
28	154.2 - 18	169.9 - 17	185.0 - 16	200.2 - 15	214.1 - 13"	228.0 - 12"
29	166.0 - 19	183.0 - 18	199.6 - 16	216.2 - 15	231.8 - 14	247.4 - 13
30	177.9 - 20	196.1 - 18	214.2 - 17	232.2 - 16	249.6 - 15	266.9 - 13
31	191.0 - 20	210.8 - 19	229.8 - 18	248.8 - 17	267.8 - 15	286.8 - 14
32	204.0 - 21	225.4 - 20	245.4 - 19	265.5 - 17	286.0 - 16	306.6 - 15
33	217.8 - 22	240.6 - 21	262.2 - 19	283.7 - 18	306.0 - 17	328.4 - 16
34	231.6 - 23	255.9 - 21	278.9 - 20	301.9 - 19	326.0 - 17	350.1 - 16
35	246.6 - 23	272.5 - 22	297.2 - 21	321.8 - 19	347.0 - 18	372.2 - 17
36	261.5 - 24	289.1 - 23	315.4 - 21	341.7 - 20	368.0 - 19	394.3 - 18
37	277.4 - 25	306.6 - 24	334.9 - 22	363.2 - 21	391.0 - 20	418.8 - 18
38	293.2 - 26	324.1 - 24	354.4 - 23	384.6 - 22	414.0 - 20	443.3 - 19
39	309.9 - 27	342.8 - 25	374.3 - 24	405.8 - 22	437.0 - 21	468.1 - 19
40	326.6 - 27	361.6 - 26	394.3 - 25	427.0 - 23	460.0 - 22	492.9 - 20

Table 23.--Gross volume (cubic feet, inside bark)
Form Class 86 Trees

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem					
	12	16	20	24	28	32
5	1.5	1.9	2.3	2.6	3.0	3.4
6	2.1	2.7	3.2	3.7	4.1	4.6
7	2.8	3.6	4.2	4.8	5.4	6.0
8	3.6	4.7	5.5	6.2	7.0	7.7
9	4.4	5.7	6.6	7.5	8.4	9.3
10	5.4	7.1	8.1	9.2	10.2	11.3

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs				
	1	1½	2	2½	3
10	7.1 - 9"	9.8 - 8"	12.6 - 7"	14.6 - 7"	16.7 - 6"
11	8.6 - 9	12.0 - 9	15.4 - 8	18.0 - 7	20.6 - 7
12	10.2 - 10	14.2 - 9	18.1 - 9	21.2 - 8	24.4 - 7
13	11.9 - 11	16.6 - 10	21.3 - 9	25.0 - 9	28.8 - 8
14	13.6 - 12	19.0 - 11	24.5 - 10	28.8 - 10	33.2 - 9
15	15.8 - 13	22.2 - 12	28.6 - 11	33.7 - 10	38.8 - 10
16	18.1 - 14	25.4 - 13	32.6 - 12	38.6 - 11	44.5 - 11
17	20.5 - 15	28.8 - 14	37.0 - 13	43.8 - 12	50.6 - 11
18	22.9 - 15	32.1 - 14	41.3 - 13	49.0 - 13	56.6 - 12
19	25.6 - 16	35.9 - 15	46.2 - 14	54.8 - 14	63.4 - 13
20	28.3 - 17	39.8 - 16	51.2 - 15	60.7 - 14	70.2 - 14
21	31.4 - 18	44.1 - 17	56.8 - 16	67.4 - 15	78.0 - 14
22	34.6 - 19	48.5 - 18	62.4 - 17	74.0 - 16	85.7 - 15
23	37.8 - 20	53.0 - 19	68.3 - 17	81.2 - 17	94.1 - 16
24	41.1 - 21	57.6 - 19	74.2 - 18	88.4 - 17	102.5 - 17
25	44.8 - 21	63.0 - 20	81.1 - 19	96.6 - 18	112.0 - 17
26	48.6 - 22	68.3 - 21	88.0 - 20	104.8 - 19	121.6 - 18
27	52.4 - 23	73.7 - 22	95.0 - 21	113.3 - 20	131.6 - 19
28	56.3 - 24	79.2 - 23	102.0 - 22	121.8 - 21	141.6 - 20
29	60.6 - 25	85.2 - 24	109.8 - 22	131.1 - 21	152.4 - 20
30	65.0 - 26	91.2 - 24	117.5 - 23	140.3 - 22	163.1 - 21
31	69.7 - 27	97.8 - 25	125.8 - 24	150.4 - 23	175.0 - 22
32	74.4 - 27	104.3 - 26	134.2 - 25	160.5 - 24	186.8 - 23
33	79.2 - 28	111.0 - 27	142.8 - 26	170.9 - 25	199.0 - 24
34	83.9 - 29	117.7 - 28	151.5 - 26	181.4 - 25	211.2 - 24
35	89.4 - 30	125.5 - 29	161.6 - 27	193.5 - 26	225.4 - 25
36	95.0 - 31	133.3 - 30	171.6 - 28	205.6 - 27	239.5 - 26
37	100.4 - 32	140.9 - 30	181.4 - 29	217.5 - 28	253.6 - 27
38	105.7 - 33	148.4 - 31	191.1 - 30	229.4 - 29	267.8 - 28
39	111.6 - 34	156.7 - 32	201.8 - 31	242.2 - 30	282.6 - 29
40	117.5 - 34	165.0 - 33	212.4 - 31	254.8 - 30	297.3 - 29

Table 23--Continued

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem						
	36	40	44	48	52	56	60
5	3.7	4.1	4.5	4.8	5.2	5.6	5.9
6	5.1	5.6	6.1	6.5	7.0	7.5	8.0
7	6.7	7.3	7.9	8.5	9.1	9.7	10.3
8	8.5	9.3	10.0	10.8	11.5	12.3	13.1
9	10.2	11.1	11.9	12.8	13.7	14.6	15.5
10	12.3	13.3	14.4	15.4	16.5	17.5	18.5

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs					
	3½	4	4½	5	5½	6
10						
11						
12	26.8 - 7"	29.1 - 6"				
13	31.6 - 7	34.5 - 7				
14	36.6 - 8	39.9 - 7				
15	43.0 - 9	47.1 - 8				
16	49.4 - 10	54.3 - 9				
17	56.2 - 10	61.8 - 10				
18	62.9 - 11	69.2 - 10				
19	70.5 - 12	77.6 - 11				
20	78.1 - 13	86.0 - 12	92.6 - 10"	99.2 - 9"		
21	86.8 - 13	95.6 - 12	103.2 - 11	110.8 - 10		
22	95.4 - 14	105.2 - 13	113.8 - 12	122.3 - 11		
23	104.6 - 15	115.2 - 14	125.0 - 13	134.7 - 12		
24	113.9 - 15	125.3 - 14	136.2 - 13	147.1 - 12		
25	124.8 - 16	137.6 - 15	149.6 - 14	161.6 - 13		
26	135.7 - 17	149.8 - 16	162.9 - 15	176.0 - 14		
27	146.8 - 18	162.0 - 17	176.4 - 15	190.7 - 14		
28	157.8 - 18	174.1 - 17	189.8 - 16	205.4 - 15	219.8 - 14"	234.1 - 12"
29	169.8 - 19	187.3 - 18	204.4 - 17	221.6 - 16	237.7 - 14	253.8 - 13
30	181.8 - 20	200.5 - 19	219.1 - 17	237.7 - 16	255.6 - 15	273.4 - 14
31	195.3 - 21	215.6 - 19	235.2 - 18	254.8 - 17	274.3 - 16	293.8 - 14
32	208.8 - 21	230.7 - 20	251.4 - 19	272.0 - 18	293.0 - 16	314.1 - 15
33	222.4 - 22	245.9 - 21	268.0 - 20	290.1 - 18	313.0 - 17	335.8 - 16
34	236.2 - 23	261.1 - 22	284.6 - 20	308.2 - 19	332.9 - 18	357.6 - 17
35	252.1 - 24	278.8 - 22	304.2 - 21	329.5 - 20	355.4 - 19	381.4 - 17
36	268.0 - 25	296.6 - 23	323.7 - 22	350.8 - 21	378.0 - 19	405.1 - 18
37	283.8 - 25	314.0 - 24	343.1 - 23	372.2 - 21	400.9 - 20	429.6 - 19
38	299.6 - 26	331.4 - 25	362.6 - 23	393.7 - 22	424.0 - 21	454.2 - 19
39	316.4 - 27	350.3 - 26	382.7 - 24	415.1 - 23	447.2 - 21	479.2 - 20
30	333.2 - 28	369.2 - 26	402.8 - 25	436.5 - 23	470.4 - 22	504.3 - 20

Table 24.--Gross volume (cubic feet, inside bark)
Form Class 87 Trees

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem					
	12	16	20	24	28	32
5	1.6	2.0	2.4	2.7	3.1	3.5
6	2.1	2.7	3.2	3.7	4.1	4.6
7	2.9	3.7	4.3	5.0	5.6	6.2
8	3.7	4.8	5.6	6.4	7.2	7.9
9	4.5	5.9	6.8	7.7	8.7	9.6
10	5.5	7.2	8.3	9.3	10.4	11.5

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs				
	1	1½	2	2½	3
10	7.2 - 9"	10.0 - 8"	12.8 - 7"	14.9 - 7"	17.0 - 6"
11	8.8 - 10	12.2 - 9	15.6 - 8	18.3 - 7	21.0 - 7
12	10.4 - 10	14.4 - 10	18.5 - 9	21.7 - 8	24.9 - 8
13	12.2 - 11	17.1 - 10	22.0 - 10	25.8 - 9	29.7 - 8
14	14.1 - 12	19.8 - 11	25.4 - 10	30.0 - 10	34.5 - 9
15	16.2 - 13	22.7 - 12	29.2 - 11	34.5 - 11	39.8 - 10
16	18.4 - 14	25.8 - 13	33.1 - 12	39.2 - 11	45.2 - 11
17	21.0 - 15	29.4 - 14	37.8 - 13	44.8 - 12	51.7 - 11
18	23.5 - 16	33.0 - 15	42.4 - 14	50.3 - 13	58.2 - 12
19	26.2 - 17	36.8 - 16	47.4 - 14	56.2 - 14	65.0 - 13
20	28.9 - 17	40.6 - 16	52.3 - 15	62.1 - 15	71.9 - 14
21	32.1 - 18	45.0 - 17	58.0 - 16	68.8 - 15	79.7 - 15
22	35.3 - 19	49.5 - 18	63.7 - 17	75.6 - 16	87.5 - 15
23	38.8 - 20	54.4 - 19	70.0 - 18	83.3 - 17	96.6 - 16
24	42.2 - 21	59.3 - 20	76.4 - 19	91.0 - 18	105.6 - 17
25	45.8 - 22	64.4 - 21	83.0 - 19	98.9 - 18	114.8 - 18
26	49.4 - 23	69.4 - 21	89.5 - 20	106.7 - 19	123.9 - 18
27	53.5 - 23	75.2 - 22	97.0 - 21	115.8 - 20	134.6 - 19
28	57.6 - 24	81.0 - 23	104.5 - 22	124.8 - 21	145.2 - 20
29	61.8 - 25	87.0 - 24	112.2 - 23	134.0 - 22	155.9 - 21
30	66.0 - 26	92.9 - 25	119.8 - 23	143.2 - 22	166.6 - 21
31	70.7 - 27	99.4 - 26	128.2 - 24	153.4 - 23	178.6 - 22
32	75.4 - 28	106.0 - 26	136.6 - 25	163.6 - 24	190.5 - 23
33	80.4 - 29	113.1 - 27	145.8 - 26	174.7 - 25	203.6 - 24
34	85.5 - 30	120.3 - 28	155.1 - 27	185.8 - 26	216.6 - 25
35	90.8 - 30	127.8 - 29	164.8 - 28	197.5 - 27	230.2 - 26
36	96.2 - 31	135.3 - 30	174.4 - 28	209.1 - 27	243.8 - 26
37	101.8 - 32	143.3 - 31	184.8 - 29	221.8 - 28	258.8 - 27
38	107.5 - 33	151.3 - 32	195.1 - 30	234.5 - 29	273.9 - 28
39	113.5 - 34	159.7 - 32	205.9 - 31	247.4 - 30	288.8 - 29
40	119.5 - 35	168.1 - 33	216.7 - 32	260.2 - 31	303.8 - 30

Table 24--Continued

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem						
	36	40	44	48	52	56	60
5	3.8	4.2	4.6	4.9	5.3	5.7	6.0
6	5.1	5.6	6.1	6.5	7.0	7.5	8.0
7	6.9	7.5	8.2	8.8	9.4	10.1	10.7
8	8.7	9.5	10.3	11.1	11.9	12.6	13.4
9	10.5	11.4	12.3	13.3	14.2	15.1	16.0
10	12.5	13.6	14.7	15.7	16.8	17.9	18.9

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs					
	3½	4	4½	5	5½	6
10						
11						
12	27.3 - 7"	29.7 - 6"				
13	32.6 - 8	35.6 - 7				
14	38.0 - 8	41.5 - 7				
15	44.1 - 9	48.4 - 8				
16	50.2 - 10	55.2 - 9				
17	57.4 - 11	63.2 - 10				
18	64.7 - 11	71.2 - 10				
19	72.3 - 12	79.6 - 11				
20	80.0 - 13	88.1 - 12	95.0 - 11"	101.8 - 10		
21	88.8 - 14	97.9 - 12	105.7 - 11	113.5 - 10		
22	97.6 - 14	107.7 - 13	116.4 - 12	125.2 - 11		
23	107.5 - 15	118.4 - 14	128.4 - 13	138.5 - 12		
24	117.4 - 16	129.2 - 15	140.5 - 14	151.8 - 12		
25	127.9 - 16	141.0 - 15	153.3 - 14	165.6 - 13		
26	138.3 - 17	152.7 - 16	166.1 - 15	179.5 - 14		
27	150.2 - 18	165.8 - 17	180.5 - 16	195.2 - 15		
28	162.0 - 19	178.8 - 18	194.9 - 16	211.0 - 15	225.8 - 14"	240.6 - 12"
29	174.0 - 19	192.0 - 18	209.6 - 17	227.2 - 16	243.8 - 15	260.4 - 13
30	185.8 - 20	205.1 - 19	224.2 - 18	243.4 - 17	261.8 - 15	280.1 - 14
31	199.4 - 21	220.3 - 20	240.5 - 18	260.7 - 17	280.6 - 16	300.6 - 15
32	213.0 - 22	235.5 - 20	256.8 - 19	278.0 - 18	299.6 - 17	321.2 - 15
33	227.7 - 23	251.8 - 21	274.6 - 20	297.4 - 19	321.0 - 17	344.6 - 16
34	242.4 - 23	268.1 - 22	292.5 - 21	316.9 - 19	342.4 - 18	367.9 - 17
35	257.6 - 24	285.1 - 23	311.2 - 21	337.3 - 20	364.0 - 19	390.6 - 18
36	273.0 - 25	302.1 - 23	329.9 - 22	357.7 - 21	385.5 - 20	413.3 - 18
37	289.8 - 26	320.7 - 24	349.2 - 23	377.6 - 22	408.6 - 20	439.6 - 19
38	306.6 - 27	339.3 - 25	368.4 - 24	397.6 - 23	431.8 - 21	465.9 - 20
39	323.6 - 27	358.5 - 26	390.4 - 25	422.2 - 23	456.8 - 22	491.3 - 20
40	340.8 - 28	377.7 - 27	412.3 - 25	446.9 - 24	481.8 - 22	516.7 - 21

Table 25.--Gross volume (cubic feet, inside bark)
Form Class 88 Trees

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem					
	12	16	20	24	28	32
5	1.6	2.0	2.4	2.8	3.2	3.5
6	2.2	2.8	3.3	3.8	4.3	4.8
7	2.9	3.8	4.4	5.1	5.7	6.3
8	3.7	4.8	5.6	6.4	7.2	7.9
9	4.6	6.0	6.9	7.8	8.8	9.7
10	5.7	7.4	8.5	9.5	10.6	11.7

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs				
	1	1½	2	2½	3
10	7.4 - 9"	10.3 - 8"	13.2 - 7"	15.4 - 7"	17.5 - 6"
11	9.0 - 10	12.6 - 9	16.1 - 8	18.8 - 8	21.6 - 7
12	10.6 - 11	14.8 - 10	19.0 - 9	22.4 - 8	25.7 - 8
13	12.4 - 11	17.4 - 11	22.4 - 10	26.4 - 9	30.4 - 9
14	14.3 - 12	20.0 - 11	25.8 - 11	30.4 - 10	35.0 - 9
15	16.6 - 13	23.3 - 12	30.0 - 11	35.4 - 11	40.8 - 10
16	18.9 - 14	26.5 - 13	34.1 - 12	40.4 - 12	46.6 - 11
17	21.4 - 15	30.0 - 14	38.6 - 13	45.7 - 12	52.8 - 12
18	23.8 - 16	33.4 - 15	43.0 - 14	51.0 - 13	59.0 - 12
19	26.7 - 17	37.5 - 16	48.3 - 15	57.4 - 14	66.4 - 13
20	29.6 - 18	41.6 - 17	53.6 - 15	63.6 - 15	73.7 - 14
21	32.8 - 18	46.1 - 17	59.4 - 16	70.6 - 16	81.9 - 15
22	36.0 - 19	50.6 - 18	65.3 - 17	77.7 - 16	90.1 - 16
23	39.3 - 20	55.4 - 19	71.4 - 18	85.0 - 17	98.7 - 16
24	42.6 - 21	60.0 - 20	77.4 - 19	92.4 - 18	107.3 - 17
25	46.4 - 22	65.4 - 21	84.4 - 20	100.8 - 19	117.1 - 18
26	50.3 - 23	70.9 - 22	91.5 - 20	109.2 - 20	126.9 - 19
27	54.2 - 24	76.4 - 23	98.6 - 21	117.8 - 20	137.1 - 19
28	58.1 - 25	82.0 - 23	105.8 - 22	126.6 - 21	147.3 - 20
29	62.8 - 25	88.5 - 24	114.2 - 23	136.6 - 22	158.9 - 21
30	67.4 - 26	95.0 - 25	122.5 - 24	146.5 - 23	170.5 - 22
31	72.2 - 27	101.8 - 26	131.3 - 25	157.2 - 24	183.1 - 23
32	77.0 - 28	108.6 - 27	140.1 - 25	167.9 - 24	195.7 - 23
33	81.8 - 29	115.4 - 28	148.9 - 26	178.5 - 25	208.1 - 24
34	86.6 - 30	122.2 - 28	157.7 - 27	189.1 - 26	220.5 - 25
35	92.2 - 31	130.1 - 29	168.0 - 28	201.5 - 27	235.0 - 26
36	97.9 - 32	138.0 - 30	178.2 - 29	213.8 - 28	249.5 - 27
37	103.3 - 33	145.7 - 31	188.1 - 30	226.0 - 29	263.9 - 28
38	108.7 - 33	153.4 - 32	198.0 - 30	238.2 - 29	278.3 - 28
39	115.0 - 34	162.2 - 33	209.5 - 31	251.9 - 30	294.3 - 29
40	121.4 - 35	171.2 - 34	221.0 - 32	265.6 - 31	310.3 - 30

Table 25.--Continued

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem						
	36	40	44	48	52	56	60
5	3.9	4.3	4.7	5.1	5.5	5.8	6.2
6	5.3	5.8	6.3	6.8	7.3	7.8	8.3
7	7.0	7.6	8.3	8.9	9.5	10.2	10.8
8	8.7	9.5	10.3	11.1	11.9	12.6	13.4
9	10.6	11.5	12.4	13.4	14.3	15.2	16.1
10	12.7	13.8	14.9	15.9	17.0	18.1	19.1

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs					
	3½	4	4½	5	5½	6
10						
11						
12	28.2 - 7"	30.8 - 6"				
13	33.4 - 8	36.5 - 7				
14	38.6 - 8	42.2 - 8				
15	45.2 - 9	49.6 - 8				
16	51.8 - 10	56.9 - 9				
17	58.7 - 11	64.6 - 10				
18	65.6 - 11	72.3 - 11				
19	73.9 - 12	81.4 - 11				
20	82.0 - 13	90.4 - 12	97.4 - 11"	104.5 - 10		
21	91.3 - 14	100.7 - 13	108.8 - 12	116.8 - 11		
22	100.6 - 15	111.0 - 13	120.1 - 12	129.2 - 11		
23	110.0 - 15	121.2 - 14	131.6 - 13	142.0 - 12		
24	119.4 - 16	131.5 - 15	143.1 - 14	154.7 - 13		
25	130.6 - 17	144.1 - 16	156.8 - 14	169.6 - 13		
26	141.8 - 18	156.7 - 16	170.6 - 15	184.4 - 14		
27	153.1 - 18	169.1 - 17	184.2 - 16	199.4 - 15		
28	164.4 - 19	181.5 - 18	198.0 - 17	214.4 - 16	229.6 - 14"	244.7 - 13"
29	177.4 - 20	195.8 - 18	213.9 - 17	232.0 - 16	249.0 - 15	266.0 - 13
30	190.4 - 20	210.2 - 19	229.8 - 18	249.5 - 17	268.4 - 16	287.3 - 14
31	204.6 - 21	226.2 - 20	247.0 - 19	267.9 - 18	288.6 - 16	309.2 - 15
32	219.0 - 22	242.3 - 21	264.3 - 20	286.3 - 18	308.7 - 17	331.1 - 16
33	233.0 - 23	257.8 - 22	281.3 - 20	304.8 - 19	329.1 - 18	353.4 - 17
34	247.0 - 24	273.4 - 22	298.4 - 21	323.4 - 20	349.5 - 18	375.6 - 17
35	263.3 - 25	291.6 - 23	318.4 - 22	345.2 - 20	372.6 - 19	400.0 - 18
36	279.6 - 25	309.7 - 24	338.4 - 23	367.0 - 21	395.7 - 20	424.4 - 19
37	295.6 - 26	327.4 - 25	358.2 - 23	389.0 - 22	419.2 - 21	449.4 - 19
38	311.8 - 27	345.2 - 25	378.0 - 24	410.9 - 23	442.7 - 21	474.5 - 20
39	330.0 - 28	365.7 - 26	400.0 - 25	434.2 - 24	468.0 - 22	501.8 - 21
40	348.2 - 29	386.2 - 27	421.8 - 26	457.4 - 24	493.2 - 23	529.1 - 21

Table 26.--Gross volume (cubic feet, inside bark)
Form Class 89 Trees

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem					
	12	16	20	24	28	32
5	1.6	2.0	2.4	2.8	3.2	3.5
6	2.2	2.8	3.3	3.8	4.3	4.8
7	2.9	3.8	4.4	5.1	5.7	6.3
8	3.8	4.9	5.7	6.5	7.3	8.0
9	4.7	6.2	7.2	8.1	9.1	10.0
10	5.8	7.6	8.7	9.8	10.9	12.0

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs				
	1	1½	2	2½	3
10	7.6 - 9"	10.6 - 8"	13.5 - 7"	15.8 - 7"	18.0 - 6"
11	9.2 - 10	12.8 - 9	16.4 - 8	19.2 - 8	22.1 - 7
12	10.8 - 11	15.1 - 10	19.4 - 9	22.8 - 8	26.2 - 8
13	12.8 - 12	17.9 - 11	23.0 - 10	27.1 - 9	31.2 - 9
14	14.8 - 12	20.8 - 12	26.7 - 11	31.5 - 10	36.3 - 9
15	17.0 - 13	23.8 - 12	30.6 - 12	36.2 - 11	41.8 - 10
16	19.1 - 14	26.8 - 13	34.5 - 12	40.9 - 12	47.3 - 11
17	21.7 - 15	30.4 - 14	39.2 - 13	46.6 - 12	53.9 - 12
18	24.3 - 16	34.2 - 15	44.0 - 14	52.2 - 13	60.5 - 13
19	27.2 - 17	38.3 - 16	49.4 - 15	58.7 - 14	68.0 - 13
20	30.2 - 18	42.5 - 17	54.8 - 16	65.1 - 15	75.4 - 14
21	33.4 - 19	47.1 - 18	60.8 - 17	72.2 - 16	83.7 - 15
22	36.7 - 20	51.7 - 18	66.7 - 17	79.4 - 17	92.0 - 16
23	40.2 - 20	56.7 - 19	73.2 - 18	87.2 - 17	101.2 - 17
24	43.8 - 21	61.8 - 20	79.7 - 19	95.1 - 18	110.5 - 17
25	47.4 - 22	66.9 - 21	86.4 - 20	103.1 - 19	119.8 - 18
26	51.1 - 23	72.1 - 22	93.1 - 21	111.2 - 20	129.2 - 19
27	55.2 - 24	78.0 - 23	100.8 - 22	120.4 - 21	140.1 - 20
28	59.4 - 25	83.9 - 24	108.4 - 22	129.7 - 21	151.0 - 20
29	63.9 - 26	90.2 - 24	116.6 - 23	139.6 - 22	162.6 - 21
30	68.4 - 27	96.6 - 25	124.8 - 24	149.4 - 23	174.1 - 22
31	73.2 - 28	103.4 - 26	133.6 - 25	160.2 - 24	186.8 - 23
32	78.0 - 28	110.2 - 27	142.5 - 26	171.0 - 25	199.4 - 24
33	83.4 - 29	117.8 - 28	152.2 - 27	182.6 - 26	213.0 - 25
34	88.8 - 30	125.4 - 29	161.9 - 27	194.2 - 26	226.6 - 25
35	94.0 - 31	132.7 - 30	171.4 - 28	205.8 - 27	240.2 - 26
36	99.1 - 32	140.0 - 31	181.0 - 29	217.4 - 28	253.8 - 27
37	104.8 - 33	148.2 - 31	191.6 - 30	230.4 - 29	269.2 - 28
38	110.6 - 34	156.4 - 32	202.1 - 31	243.4 - 30	284.6 - 29
39	117.0 - 35	165.4 - 33	213.8 - 32	257.3 - 31	300.8 - 30
40	123.4 - 36	174.4 - 34	225.4 - 33	271.2 - 32	316.9 - 31

Table 26.--Continued

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem						
	36	40	44	48	52	56	60
5	3.9	4.3	4.7	5.1	5.5	5.8	6.2
6	5.3	5.8	6.3	6.8	7.3	7.8	8.3
7	7.0	7.6	8.3	8.9	9.5	10.2	10.8
8	8.8	9.6	10.4	11.2	12.0	12.7	13.5
9	11.0	11.9	12.9	13.8	14.8	15.7	16.7
10	13.1	14.2	15.3	16.4	17.5	18.6	19.7

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs					
	3½	4	4½	5	5½	6
10						
11						
12	28.8 - 7"	31.4 - 6"				
13	34.4 - 8	37.6 - 7				
14	40.0 - 9	43.8 - 8				
15	46.3 - 9	50.8 - 9				
16	52.6 - 10	57.8 - 9				
17	60.0 - 11	66.0 - 10				
18	67.4 - 12	74.2 - 11				
19	75.7 - 12	83.4 - 11				
20	84.0 - 13	92.6 - 12	99.9 - 11"	107.2 - 10"		
21	93.4 - 14	103.0 - 13	111.4 - 12	119.7 - 11		
22	102.8 - 15	113.5 - 14	122.8 - 13	132.2 - 12		
23	112.9 - 15	124.6 - 14	135.2 - 13	145.9 - 12		
24	123.0 - 16	135.6 - 15	147.6 - 14	159.6 - 13		
25	133.7 - 17	147.6 - 16	160.7 - 15	173.8 - 14		
26	144.4 - 18	159.6 - 17	173.8 - 15	188.0 - 14		
27	156.5 - 19	172.9 - 17	188.5 - 16	204.1 - 15		
28	168.6 - 19	186.2 - 18	203.2 - 17	220.2 - 16	235.8 - 14"	251.4 - 13"
29	181.6 - 20	200.5 - 19	219.2 - 18	237.8 - 17	255.3 - 15	272.8 - 14
30	194.4 - 21	214.8 - 19	235.0 - 18	255.3 - 17	274.7 - 16	294.1 - 15
31	208.9 - 22	231.0 - 20	252.4 - 19	273.8 - 18	295.0 - 17	316.2 - 15
32	223.4 - 22	247.3 - 21	269.8 - 20	292.4 - 19	315.4 - 17	338.4 - 16
33	238.6 - 23	264.2 - 22	288.4 - 21	312.6 - 19	337.6 - 18	362.6 - 17
34	253.9 - 24	281.2 - 23	307.0 - 21	332.9 - 20	359.8 - 19	386.8 - 18
35	269.2 - 25	298.3 - 23	325.8 - 22	353.4 - 21	381.6 - 20	409.8 - 18
36	284.6 - 26	315.4 - 24	344.7 - 23	374.0 - 22	403.4 - 20	432.7 - 19
37	301.8 - 26	334.4 - 25	366.0 - 24	397.5 - 22	428.6 - 21	459.6 - 20
38	319.0 - 27	353.4 - 26	387.2 - 25	421.0 - 23	453.8 - 22	486.5 - 20
39	337.5 - 28	374.2 - 27	409.4 - 25	444.6 - 24	479.4 - 22	514.2 - 21
40	355.9 - 29	394.9 - 28	431.5 - 26	468.1 - 25	505.0 - 23	541.8 - 22

Table 27.--Gross volume (cubic feet, inside bark)
Form Class 90 Trees

Tree diameter (inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem					
	12	16	20	24	28	32
5	1.6	2.1	2.5	2.9	3.3	3.7
6	2.3	2.9	3.4	3.9	4.5	5.0
7	3.0	3.9	4.6	5.2	5.9	6.5
8	3.9	5.0	5.8	6.6	7.4	8.2
9	4.8	6.3	7.3	8.2	9.2	10.1
10	5.9	7.7	8.8	10.0	11.1	12.2

Tree diameter (inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs				
	1	1½	2	2½	3
10	7.7 - 9"	10.8 - 8"	13.8 - 8"	16.0 - 7"	18.3 - 6"
11	9.3 - 10	13.0 - 9	16.8 - 8	19.6 - 8	22.5 - 7
12	10.9 - 11	15.3 - 10	19.7 - 9	23.2 - 9	26.7 - 8
13	13.0 - 12	18.2 - 11	23.4 - 10	27.6 - 9	31.8 - 9
14	15.0 - 13	21.0 - 12	27.1 - 11	32.0 - 10	36.9 - 10
15	17.2 - 13	24.2 - 13	31.2 - 12	36.9 - 11	42.6 - 10
16	19.4 - 14	27.4 - 13	35.3 - 12	41.8 - 12	48.4 - 11
17	22.0 - 15	31.0 - 14	40.0 - 13	47.6 - 13	55.1 - 12
18	24.6 - 16	34.7 - 15	44.8 - 14	53.3 - 13	61.8 - 13
19	27.6 - 17	38.9 - 16	50.2 - 15	59.8 - 14	69.4 - 14
20	30.5 - 18	43.1 - 17	55.7 - 16	66.3 - 15	76.9 - 14
21	34.0 - 19	47.9 - 18	61.8 - 17	73.6 - 16	85.4 - 15
22	37.4 - 20	52.7 - 19	68.0 - 18	81.0 - 17	93.9 - 16
23	41.0 - 21	57.8 - 20	74.6 - 18	89.0 - 18	103.3 - 17
24	44.6 - 22	62.9 - 20	81.2 - 19	97.0 - 18	112.7 - 18
25	48.5 - 22	68.4 - 21	88.4 - 20	105.6 - 19	122.7 - 18
26	52.4 - 23	74.0 - 22	95.5 - 21	114.1 - 20	132.7 - 19
27	56.6 - 24	79.9 - 23	103.2 - 22	123.5 - 21	143.8 - 20
28	60.8 - 25	85.9 - 24	111.0 - 23	132.9 - 22	154.8 - 21
29	65.4 - 26	92.4 - 25	119.4 - 24	142.9 - 23	166.4 - 22
30	69.9 - 27	98.8 - 26	127.7 - 24	152.9 - 23	178.1 - 22
31	74.8 - 28	105.7 - 26	136.6 - 25	163.8 - 24	191.0 - 23
32	79.6 - 29	112.6 - 27	145.5 - 26	174.6 - 25	203.8 - 24
33	84.8 - 30	119.9 - 28	155.0 - 27	186.1 - 26	217.2 - 25
34	89.9 - 31	127.2 - 29	164.5 - 28	197.6 - 27	230.7 - 26
35	95.4 - 31	135.0 - 30	174.7 - 29	210.0 - 28	245.2 - 27
36	100.9 - 32	142.9 - 31	184.9 - 30	222.4 - 29	259.8 - 27
37	107.0 - 33	151.4 - 32	195.9 - 30	235.8 - 29	275.6 - 28
38	113.1 - 34	160.0 - 33	206.9 - 31	249.2 - 30	291.5 - 29
39	119.6 - 35	169.1 - 34	218.6 - 32	263.2 - 31	307.8 - 30
40	126.0 - 36	178.2 - 34	230.4 - 33	277.3 - 32	324.2 - 31

Table 27.--Continued

Tree iameter inches)	Cordwood volume (cubic feet, inside bark) by length (feet) of merchantable stem						
	36	40	44	48	52	56	60
5	4.1	4.5	4.9	5.3	5.7	6.1	6.5
6	5.5	6.0	6.6	7.1	7.6	8.1	8.7
7	7.2	7.9	8.5	9.2	9.8	10.5	11.2
8	9.1	9.9	10.7	11.5	12.3	13.1	13.9
9	11.1	12.0	13.0	13.9	14.9	15.8	16.8
10	13.4	14.5	15.6	16.8	17.9	19.0	20.2

Tree iameter inches)	Sawlog volume (cubic feet, inside bark) and scaling diameter (inches) of top sawlog, by number of 16-foot logs					
	3½	4	4½	5	5½	6
10						
11						
12	29.4 - 7"	32.0 - 6"				
13	35.0 - 8	38.3 - 7				
14	40.8 - 9	44.6 - 8				
15	47.3 - 10	52.0 - 9				
16	53.8 - 10	59.3 - 9				
17	61.4 - 11	67.6 - 10				
18	68.8 - 12	75.9 - 11				
19	77.3 - 13	85.2 - 12				
20	85.7 - 13	94.5 - 12	102.0 - 11"	109.5 - 10"		
21	95.3 - 14	105.2 - 13	113.8 - 12	122.4 - 11		
22	105.0 - 15	116.0 - 14	125.6 - 13	135.2 - 12		
23	115.2 - 16	127.2 - 15	138.1 - 14	149.0 - 12		
24	125.6 - 16	138.4 - 15	150.6 - 14	162.9 - 13		
25	137.0 - 17	151.2 - 16	164.7 - 15	178.2 - 14		
26	148.4 - 18	164.1 - 17	178.8 - 16	193.4 - 15		
27	160.7 - 19	177.6 - 18	193.6 - 16	209.7 - 15		
28	173.0 - 20	191.1 - 18	208.6 - 17	226.0 - 16	242.1 - 15"	258.2 - 13"
29	186.0 - 20	205.6 - 19	224.7 - 18	243.8 - 17	261.8 - 15	279.8 - 14
30	199.0 - 21	220.0 - 20	240.8 - 19	261.6 - 18	281.6 - 16	301.5 - 15
31	213.7 - 22	236.4 - 21	258.4 - 19	280.4 - 18	302.2 - 17	323.9 - 16
32	228.4 - 23	252.9 - 21	276.0 - 20	299.2 - 19	322.8 - 18	346.3 - 16
33	243.5 - 24	269.8 - 22	294.6 - 21	319.4 - 20	345.0 - 18	370.5 - 17
34	258.6 - 24	286.6 - 23	313.0 - 22	339.5 - 20	367.1 - 19	394.7 - 18
35	275.0 - 25	304.9 - 24	333.2 - 22	361.6 - 21	390.5 - 20	419.4 - 19
36	291.5 - 26	323.2 - 25	353.4 - 23	383.7 - 22	413.9 - 21	444.1 - 19
37	309.2 - 27	342.8 - 25	375.3 - 24	407.8 - 23	439.7 - 21	471.6 - 20
38	326.9 - 28	362.3 - 26	397.0 - 25	431.8 - 24	465.5 - 22	499.2 - 21
39	345.6 - 29	383.3 - 27	419.4 - 26	455.6 - 24	491.4 - 23	527.2 - 21
40	364.2 - 29	404.3 - 28	441.9 - 27	479.5 - 25	517.4 - 24	555.2 - 22

Table 28 —Area of circles in square feet (basal area table)[1]

Diameter Inches	Diameter—tenths of inches										Diameter Inches
	0.0	0.1	0.2	0.3	0.4	0.5	0.6	0.7	0.8	0.9	
	Area—square feet										
						0.001	0.002	0.003	0.003	0.004	
1	0.005	0.007	0.008	0.009	0.011	.012	.014	.016	.018	.020	1
2	.022	.024	.026	.029	.031	.034	.037	.040	.043	.046	2
3	.049	.052	.056	.059	.063	.067	.071	.075	.079	.083	3
4	.087	.092	.096	.101	.106	.110	.115	.120	.126	.131	4
5	.136	.142	.147	.153	.159	.165	.171	.177	.183	.190	5
6	.196	.203	.210	.216	.223	.230	.238	.245	.252	.260	6
7	.267	.275	.283	.291	.299	.307	.315	.323	.332	.340	7
8	.349	.358	.367	.376	.385	.394	.403	.413	.422	.432	8
9	.442	.452	.462	.472	.482	.492	.503	.513	.524	.535	9
10	.545	.556	.567	.579	.590	.601	.613	.624	.636	.648	10
11	.660	.672	.684	.696	.709	.721	.734	.747	.759	.772	11
12	.785	.799	.812	.825	.839	.852	.866	.880	.894	.908	12
13	.922	.936	.950	.965	.979	.994	1.009	1.024	1.039	1.054	13
14	1.069	1.084	1.100	1.115	1.131	1.147	1.163	1.179	1.195	1.211	14
15	1.227	1.244	1.260	1.277	1.294	1.310	1.327	1.344	1.362	1.379	15
16	1.396	1.414	1.431	1.449	1.467	1.485	1.503	1.521	1.539	1.558	16

17	1.576	1.595	1.614	1.632	1.651	1.670	1.689	1.709	1.728	1.748	17
18	1.767	1.787	1.807	1.827	1.847	1.867	1.887	1.907	1.928	1.948	18
19	1.969	1.990	2.011	2.032	2.053	2.074	2.095	2.117	2.138	2.160	19
20	2.182	2.204	2.226	2.248	2.270	2.292	2.315	2.337	2.360	2.382	20
21	2.405	2.428	2.451	2.474	2.498	2.521	2.545	2.568	2.592	2.616	21
22	2.640	2.664	2.688	2.712	2.737	2.761	2.786	2.810	2.835	2.860	22
23	2.885	2.910	2.936	2.961	2.986	3.012	3.038	3.064	3.089	3.115	23
24	3.142	3.168	3.194	3.221	3.247	3.274	3.301	3.328	3.355	3.382	24

Diameter	Area	Diameter	Area	Diameter	Area	Diameter	Area	Diameter	Area
Inches	Sq. ft.	Inches	Sq. ft.	Inches	Sq. ft.	Inches	Sq. ft.	Inches	Sq. ft.
25	3.409	32	5.585	39	8.296	46	11.541	53	15.321
26	3.687	33	5.940	40	8.727	47	12.048	54	15.904
27	3.976	34	6.305	41	9.168	48	12.566	55	16.499
28	4.276	35	6.681	42	9.621	49	13.095	56	17.104
29	4.587	36	7.069	43	10.085	50	13.635	57	17.721
30	4.909	37	7.467	44	10.559	51	14.186	58	18.348
31	5.241	38	7.876	45	11.045	52	14.748	59	18.986

1/ Revised and checked by Southern Forest Experiment Station with Basal Area Table, "Forest Mensuration," by H. H. Chapman.

APPENDIX

Converting Cubic Volume Inside Bark to Rough Cords

The preceding tables for cubic-foot volume inside bark are designed for making precise estimates of volume of usable wood, exclusive of bark. When cord measure including bark is desired, the timber manager should use tables based on measurements outside bark. Such tables allow cubic-foot volume of wood and bark together to be computed directly without reference to bark thickness. Examples of such tables are the Southern Forest Experiment Station's form point cubic-foot volume tables, including bark,[1] for second-growth southern pine.

Cubic-foot volume i.b., as obtained from the tables presented in this paper, may be converted approximately to stacked cords of wood and bark by the factors given below. Since these factors were compiled for broad zones in the South, they should be carefully checked before being applied in any given area; local peculiarities may otherwise cause large errors.

1/ U. S. Forest Service. Volume tables, converting factors, and other information applicable to commercial timber in the South. Ed. 4, pp. 5-6. Atlanta, Ga. 1942. (Processed.)

Locality	To get rough cords, divide i.b. volume in cu. ft. by:	
	For pine	For hdwds.
Alabama		
Naval stores region	74.9	65.1
Remainder of State	75.9	65.4
Arkansas		
Delta region	73.4	66.7
Southern pine-hardwood region	76.7	65.6
Northwest pine-hardwood region	(1/)	(1/)
Florida	74.1	67.0
Georgia		
Northern pine-hardwood region	76.1	65.5
Naval stores region	74.2	65.5
Louisiana		
Delta region	74.1	67.5
Western pine-hardwood region	76.3	66.3
Naval stores region	75.3	66.0
Mississippi		
Delta region	...	69.9
Central pine-hardwood region	75.5	65.6
Naval stores region	75.1	65.0
Oklahoma	78.0	64.9
Texas	76.3	65.5

1/ No figures available.

A slightly more accurate approximation can be made by obtaining representative local samples of $\frac{\text{o.b.volume}}{\text{i.b.volume}}$ ratio for each d.b.h. class and species, and then multiplying the cubic-foot i.b. volume in each d.b.h. class and species by the corresponding ratio. The ratio is most easily computed as:

$$\frac{\text{Butt d.o.b.}^2 + 2[\text{mid d.o.b.}^2] + \text{top d.o.b.}^2}{\text{Butt d.i.b.}^2 + 2[\text{mid d.i.b.}^2] + \text{top d.i.b.}^2}.$$

This method allows for bark fluctuation due to species, height, and d.b.h., but it involves sampling felled trees and measuring in inches the diameter (both inside and outside bark) at stump, at cut nearest mid-point of merchantable bole, and at merchantable top.

To make the computations, square each of the above measurements, then weight the squared mid-point values by doubling them. Sum the squared o.b. measurements (with mid-point values weighted as above) for all samples within a species-d.b.h. class, and divide by the sum of the corresponding squared i.b. measurements (with mid-point values weighted as above). The resulting quotient is the proper factor, within a species-d.b.h. class, by which to multiply cubic-foot volume of wood inside bark in order to convert to cubic-foot volume of wood, including bark.

To convert cubic volume outside bark to cords, divide by 90 for pine and by 80 for hardwood. Diameter, length, straightness, and knottiness of stick all influence the number of cubic feet in a cord. If it is desirable to allow for these variations in $\frac{\text{cord}}{\text{o.b. volume}}$ ratio, consult the factors for each average stick condition given in the Lake States Forest Experiment Station Forest Research Digest for May 1935, page 5.

Table 29.—Gross volume (cubic feet, inside bark) in merchantable tops of sawlog-size southern pines

Scaling diameter top sawlog (inches)	Gross volume (cubic feet, inside bark) by length of merchantable top section in feet						Scaling diameter top sawlog (inches)					
	4	8	12	16	20	24		28	32	36	40	44
Trees of high top form index												
5	0.4	0.8	1.2	1.5	1.9	2.3	5	2.7	3.1	3.5	3.8	4.2
6	0.6	1.1	1.7	2.3	2.8	3.4	6	4.0	4.5	5.1	5.7	6.2
7	0.8	1.6	2.4	3.1	3.9	4.7	7	5.5	6.3	7.1	7.9	8.6
8	1.0	2.0	3.0	4.0	5.0	6.1	8	7.1	8.1	9.1	10.1	11.1
9	1.3	2.5	3.8	5.0	6.3	7.6	9	8.8	10.1	11.3	12.6	13.9
10	1.6	3.2	4.7	6.3	7.9	9.5	10	11.0	12.6	14.2	15.8	17.3
11	1.9	3.9	5.8	7.7	9.6	11.6	11	13.5	15.4	17.3	19.3	21.2
12	2.3	4.5	6.8	9.1	11.4	13.6	12	15.9	18.2	20.4	22.7	25.0
13	2.6	5.3	7.9	10.6	13.2	15.8	13	18.5	21.1	23.8	26.4	29.0
14	3.1	6.2	9.3	12.4	15.4	18.5	14	21.6	24.7	27.8	30.9	34.0
15	3.6	7.1	10.7	14.3	17.9	21.4	15	25.0	28.5	32.2	35.7	39.3
16	4.0	8.1	12.1	16.1	20.2	24.2	16	28.2	32.3	36.3	40.4	44.4
17	4.5	9.0	13.6	18.1	22.6	27.1	17	31.7	36.2	40.7	45.2	49.8
18	5.1	10.2	15.3	20.4	25.5	30.6	18	35.8	40.9	46.0	51.1	56.2
19	5.7	11.5	17.2	22.9	28.6	34.4	19	40.1	45.8	51.5	57.3	63.0
20	6.3	12.6	18.9	25.2	31.5	37.8	20	44.1	50.4	56.7	63.1	69.4
Trees of average top form index												
5	0.3	0.6	0.9	1.3	1.6	1.9	5	2.2	2.5	2.8	3.2	3.5
6	0.4	0.9	1.3	1.8	2.2	2.6	6	3.1	3.5	4.0	4.4	4.9
7	0.6	1.2	1.8	2.5	3.1	3.7	7	4.3	4.9	5.5	6.1	6.7
8	0.8	1.6	2.4	3.1	3.9	4.7	8	5.5	6.3	7.1	7.9	8.6
9	1.0	2.0	3.0	4.0	5.0	6.1	9	7.1	8.1	9.1	10.1	11.1
10	1.2	2.5	3.7	4.9	6.1	7.4	10	8.6	9.8	11.0	12.3	13.5
11	1.5	3.0	4.5	6.0	7.5	9.0	11	10.5	12.0	13.5	15.0	16.5
12	1.8	3.5	5.3	7.1	8.8	10.6	12	12.4	14.1	15.9	17.7	19.4
13	2.1	4.2	6.3	8.4	10.5	12.6	13	14.7	16.8	18.9	21.0	23.0
14	2.4	4.8	7.2	9.6	12.0	14.4	14	16.8	19.2	21.6	24.1	26.5
15	2.8	5.6	8.4	11.1	13.9	16.7	15	19.5	22.3	25.1	27.9	30.6
16	3.1	6.3	9.4	12.6	15.7	18.8	16	22.0	25.1	28.3	31.4	34.6
17	3.6	7.1	10.7	14.3	17.9	21.4	17	25.0	28.6	32.2	35.7	39.3
18	4.0	8.0	11.9	15.9	19.9	23.9	18	27.8	31.8	35.8	39.8	43.7
19	4.5	8.9	13.4	17.8	22.3	26.8	19	31.2	35.7	40.2	44.6	49.1
20	4.9	9.8	14.7	19.6	24.5	29.5	20	34.4	39.3	44.2	49.1	54.0
Trees of low top form index												
5	0.3	0.5	0.8	1.0	1.3	1.5	5	1.8	2.0	2.3	2.5	2.8
6	0.3	0.7	1.0	1.4	1.7	2.1	6	2.4	2.8	3.1	3.5	3.8
7	0.5	1.0	1.4	1.9	2.4	2.9	7	3.4	3.8	4.3	4.8	5.3
8	0.6	1.3	1.9	2.5	3.2	3.8	8	4.5	5.1	5.7	6.4	7.0
9	0.8	1.6	2.4	3.1	3.9	4.7	9	5.5	6.3	7.1	7.8	8.6
10	1.0	2.0	2.9	3.9	4.9	5.9	10	6.9	7.8	8.8	9.8	10.8
11	1.2	2.4	3.6	4.8	6.0	7.2	11	8.4	9.6	10.8	12.0	13.2
12	1.4	2.8	4.2	5.6	7.0	8.4	12	9.8	11.2	12.6	14.0	15.4
13	1.7	3.3	5.0	6.6	8.3	9.9	13	11.6	13.2	14.9	16.5	18.2
14	1.9	3.9	5.8	7.7	9.6	11.6	14	13.5	15.4	17.4	19.3	21.2
15	2.2	4.4	6.5	8.7	10.9	13.1	15	15.3	17.4	19.6	21.8	24.0
16	2.5	5.0	7.5	10.0	12.5	15.0	16	17.5	20.0	22.5	25.0	27.5
17	2.8	5.7	8.5	11.3	14.2	17.0	17	19.9	22.7	25.5	28.4	31.2
18	3.2	6.4	9.6	12.8	16.0	19.2	18	22.4	25.6	28.8	32.0	35.2
19	3.5	7.0	10.6	14.1	17.6	21.1	19	24.6	28.2	31.7	35.2	38.7
20	3.9	7.8	11.7	15.7	19.6	23.5	20	27.4	31.3	35.2	39.2	43.1

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GET YOUR MONEY'S WORTH FROM FORESTRY

By
R.R.Reynolds

SOUTHERN FOREST EXPERIMENT STATION
Chas. A. Connaughton, Director
New Orleans, La.

GET YOUR MONEY'S WORTH FROM FORESTRY[1]

By R. R. Reynolds
Southern Forest Experiment Station

Intensive forest management in the South dates from about 1935. Altogether we have made excellent progress, and as a region should be proud of the fact that we have more forest land under real management than any other section of the country. The companies making up the pulpwood industry in the South are to be complimented on having placed a very high percentage of their lands under management and on the effort they have made to sell better cutting practices to small timberland owners.

Although accomplishments have been many, there is still a huge job to be done before all commercial forest land has the fire protection and management so necessary to the well-being of all the people of the South. The Reappraisal of the forest situation made by the U. S. Forest Service in 1945 and 1946 indicated what a large job we have to do in the South before we can begin to realize the possibilities offered us by good land, a long growing season, good species, and favorable markets. The Reappraisal Report indicated that large owners (holding 50,000 acres or more) are, in general, doing a creditable job of managing their timberlands. Sixty-six percent of the cutting on lumber company lands was of fair to high order. Cutting on pulp company holdings was even better: 89 percent of it was of fair to high order.

Those of us who are managing timberland, however, often lose sight of the fact that large ownerships make up only a relatively small percentage of the total forest land in the South. Actually, large ownerships number only 219 and control only 23 million acres of forest land. Contrasted to this, owners of small holdings number

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1/ Paper delivered at the Southern Pulpwood Conservation Association meeting at Atlanta, Georgia, January 28, 1948.

1,650,000 and control 122 million acres of forest land. At the time of the Reappraisal, 74 percent of the cutting on these small holdings was poor or destructive. Since the pulp industry has dealings with many of these owners, the industry can have a great influence on the type of management practiced. In fact, the industry has a chance to help itself by helping these small owners to realize greater returns through good forest management.

Even though owners of large acreages of forest land have accomplished a great deal in the past 10 years, this is no time for any of us, whether State, Federal, or private, to swell up with pride and assume that everything is known about forest management. Neither have we any right to assume that the management we are practicing is intensive management and that we are getting all the returns per acre that it is possible to get. Actually, we are only getting about half our money's worth from our so-called intensively managed stands. This means that owners of large acreages of forest land as well as owners of small tracts are losing money every day--plenty of it.

I would like to back up this conclusion by describing some of the results that have been obtained during the last 10 years from studies under way on the Crossett Experimental Forest. As most of you know, the Experimental Forest is a part of the Southern Forest Experiment Station. The original unit of the forest was given to the U. S. Forest Service by the Crossett Lumber Company. The experimental work deals with problems of the upland loblolly-shortleaf pine-hardwood type.

Low-Grade Hardwoods a Big Problem

When the area now contained in the Experimental Forest was accepted in 1934, the tract had a fairly good stand of second-growth pine ranging from 4 to 20 inches in diameter and averaging about 3,300 board feet (Doyle scale), or 14 cords per acre.

In addition to the pine, the stand also contained a very large number of low-grade hardwoods of many species. Some of these were of quite large size. Most of them were from about 3 to 10 inches in diameter. Many of them had come in as a result of the opening up of the stands by the heavy cutting of 1915. Others were a result of repeated uncontrolled fires that kept out the pine and favored the hardwood.

In some few places, these low-grade hardwoods occupied only a small portion of the effective pine growing space. In other places, they covered whole areas solidly, leaving little or no chance for pine to become established or for the pine already present to grow.

It has been estimated that on the average these weed trees were occupying or would soon occupy nearly 50 percent of the growing space.

The Crossett Branch has accomplished some quite remarkable things by a hardwood removal program. Today there are dense stands of pine of near-pulpwood size on areas that in 1939 were almost completely taken over by the hardwoods. In these areas, there are at least 3 cords of pulpwood-size pine material per acre at the end of the first 10-year period. Furthermore, these stands are just getting into condition and, if handled correctly, will produce very good incomes for the next 50 to 60 years without an additional girdling operation. Reasonably well-stocked stands of pine will grow 500 board feet or 1 cord or more per acre per year. Did it pay to eliminate the poor-grade hardwoods?

At the present time, pine stumpage west of the Mississippi commonly ranges between $20 and $40 per M board feet, or from $2.00 to $3.50 per standard cord for pulpwood. If a relatively low value of $20 per M for sawlogs, or $2.50 per cord for pulpwood, is used and applied to the annual growth of 500 board feet of saw timber, or to 1 cord of pulpwood, then every year that low-grade hardwoods are allowed to occupy half of the pine stands at Crossett we are losing $5 per acre in saw-timber stands or $1.25 per acre in pulpwood stands. Other timberland owners are likewise losing this potential income. This loss is just about as real as if it were coming out of the owner's pocket because he already has a large investment in land, timber, and carrying charges. Poisoning or girdling the hardwoods cost $1 to $3 per acre at Crossett so the value of the 3 cords of pulpwood grown in the first 10 years following hardwood elimination is worth about three times this cost.

I do not mean to suggest that all hardwoods should be removed from all our timberland. On good hardwood sites, the better hardwoods, such as white oak, yellow poplar, and ash, probably will yield more income than pine. Even on the better pine sites, commercially valuable hardwoods may be very desirable in mixture with pine. Some hardwoods are needed in pine stands to keep up the fertility of the soil. At the same time, low-grade hardwoods should very definitely be kept under control on pine sites because they are causing a huge present and potential loss of income.

Planting Will Pay in Many Cases

There are many, many acres of good pine growing land from which all the pine has been cut, leaving no way for the area to reseed naturally. Thousands of other acres of abandoned farm land in our pine types will require a good many years to reseed naturally. And, finally, there are many thousands of other acres with a very light stocking of small trees that are producing only a small fraction of their potential amount of forest products. Some of these open areas are within shouting distance of some of our pulp mills. Apparently, no effort is being made to plant them. Undoubtedly, it is hoped that such areas will reseed naturally to a full stand. While the owners are waiting for that to happen, they are buying wood from 200 to 300 miles away and paying a freight rate of $3 to $5 per cord.

Timberland owners can, with modern tree planters, plant such areas at a cost of $8 to $12 per acre. Thus the freight that is being paid on 2 to 3 cords of wood hauled these long distances would pay for planting one of these nearby idle acres on which 1 to 2 cords of pulpwood can be grown annually. Again the owners are losing $2 to $4 of potential gross income from stumpage every year that they wait. The only excuse for not developing a dense stand immediately is a plan to go out of business within 15 to 20 years.

High Returns Possible from Well-Spaced, Immature Trees

It is quite common practice for many small sawmills as well as some of the larger ones to obtain their logs by clear-cutting the stands to a very low diameter limit. The same is true for a large percentage of the pulpwood operators in the South. Contractors will buy stands "lump sum" from the owners and then clear-cut them of everything that will make a pulpwood stick with a 3-inch top diameter.

Providing enough seed trees are reserved, such a cutting policy is not bad if the stands in question are even-aged and the trees are mature for the products wanted. There is nothing wrong with even-aged management; it may be the type of management best suited to the production of pulpwood. However, for every example of clear-cutting in mature or near-mature stands, there are 100 examples of the clear-cutting of all-aged and wholly immature even-aged stands that have just developed to the point where they will yield good annual returns to the owner for a long period of time if properly managed.

I realize that the owners of the stands in question often wish to have their woods clear-cut and think they are making a smart deal. In many other cases, the contractors will only buy on a clear-cutting deal or at least talk the owners into such a proposition.

But just how good a deal is such a cutting policy in immature stands? Well-spaced pine trees in the South will usually increase in diameter at an average rate of 1 inch in 3 years or 3-1/3 inches in 10 years. Four-inch trees will increase 114 percent in volume and value as pulpwood in growing to 5 inches in size.

This means that these 4-inch trees are earning interest on the investment of 38 percent per year! Similarly, 5-inch trees growing 1 inch in diameter in 3 years are increasing in value at a rate of 27 percent per year. Under the same conditions of growth and again assuming the trees are to be sold for pulpwood, 6-inch trees will increase in value at 23 percent per year; 8-inch trees will make 12 percent per year; 10-inch trees will make 9 percent a year, and 12-inch trees will make 7 percent a year.

If we are considering the production of saw timber, and we assume that good, well-spaced trees will grow 1 inch in diameter in 3 years, a 9-inch tree will increase 46 percent per year in volume and value in growing to 10 inches. Ten-inch trees will increase at the rate of 30 percent per year; 14-inch trees will increase annually at the rate of 13 percent; and 16-inch trees will increase 10 percent a year.

Now--do you know of any reasonably safe investment you can make with the money obtained from trees of these sizes that will yield a return from 10 to 40 percent per year? If so, an owner is justified in clear-cutting good, fast-growing, immature trees of the sizes indicated. If not--and "not" is the usual answer--then these trees should be allowed to grow until they are financially mature or until they slow up in growth and earn a relatively low rate of interest.

There is every reason for thinning immature stands in order to remove the suppressed, diseased, and limby trees, and to give the good trees room to grow. Such a thinning is usually necessary every few years. But harvesting the good trees before they are 10 to 12 inches in diameter on a pulpwood operation and from 18 to 24 inches for a sawlog operation is distinctly poor business from the landowner's standpoint.

Crossett Farm Forestry Forty Shows Timber-Growing Possibilities

The Crossett farm forestry study should interest all timberland owners because it indicates the growth, yield, and returns that can be expected from a large share of our forest land in the South once the stocking is built up to a reasonable level. In 1937 forty acres of second-growth shortleaf-loblolly pine were selected for management as a farm woodlot. It was planned to make an annual harvest of forest products from the area to see if timber could not be as much an annual farm crop as corn, cotton, or potatoes.

The volume of growing stock and the total amount of growth produced during the first year of management were first determined by a 100-percent inventory and a growth study. Next, a number of the larger and less valuable trees, having a volume equivalent to the growth during the year, were marked for cutting. These marked trees were then cut into the products for which they were best suited. Parts of some trees made logs, other parts yielded pulpwood and posts, and the low-grade, rough hardwood tops were made into firewood.

Ten such annual cuts have been made from the 40-acre tract to date. Yet, today the volume of the stand is almost identical to that present when the study was started in 1937. Moreover, since most of the low-quality trees were removed in the first years of the study, the quality of the stand is much better than when the study started. These 10 annual cuts have produced 122,197 board feet (Doyle rule) of logs, 281 cords of pulpwood, 171 cords of fuelwood, and 313 fence posts. These products had a value of $1,741 in the standing tree and a market value of $5,995. These figures represent a stumpage return of $43.53 per acre and a market value of $149.87 per acre for the 10-year period.

The results of this study indicate that timber properly managed will yield large returns and is or can be as much an annual crop as corn or cotton. Furthermore, since approximately 1,000 pounds of cellulose can be obtained from 1 standard cord of wood, the 40-acre farm woodlot is producing yearly approximately 27,900 pounds of cellulose. This is equal to 700 pounds per acre. It forcibly demonstrates that well-stocked stands of trees can produce more cellulose than cotton does on much of the hill land. Cotton often yields less than 300 pounds of cellulose per acre.

Although this is called a farm woodland study, the results can apply equally well to timberland in other classes of ownership. You may not harvest a crop from each acre of your forest land each year, but you could get about the same results if you made a harvest every 5 years.

In times past, it has been common practice to say that if a given piece of land was not valuable for agriculture, or grazing, or recreation, or something else, it could and should be called "forest" land and trees grown on it. In other words, the forest was supposed to contain any old piece of land that no one else wanted. I believe that the Farm Forestry Forty has proven that, on a very large percentage of our uplands throughout the South, timber does not need to take a back seat to any crop.

Summary

Summing up, just remember that your expenses of management per acre per year are generally the same regardless of the amount of wood produced. The wood you will get per acre per year depends upon the amount of growing stock of desirable species you have and how you handle it. At the present time, most of the stands are badly understocked. They are too thick in some spots and far too thin in others. They contain wolf trees and slow-growing trees and much low-grade hardwood that is cutting down the growth of good trees by nearly one-half. A large amount of open and non-restocking forest land close to the mills needs to be planted. At the same time, the mills are paying a freight charge of $3 to $5 per cord on wood from 200 to 300 miles away. In general, owners of timberland are not getting anywhere near their money's worth from their stands. If you are not, and you intend to be in business for some time to come, you had better take advantage of your opportunities. You can't afford not to.

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LUMBER VALUES
FOR EAST TEXAS PINE LOGS

By
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LUMBER VALUES FOR EAST TEXAS PINE LOGS

By G. R. Gregory and H. L. Person[1/]
Southern Forest Experiment Station

Introduction

Progressive lumbermen know that it costs more to produce lumber from small logs than from larger logs, and that on the average the unit value of lumber produced increases with both log diameter and quality. However, measuring the difference between costs and values for logs or trees of different size or quality classes requires detailed studies of sawmill operations.

The most complete southern study of this kind was made by the Southern Forest Experiment Station in cooperation with the Crossett Lumber Company between 1935 and 1938 (4). This, like the former southern pine milling studies (1), was made at a large band mill--in which the cost of handling small logs is generally higher than at the small or medium-sized circular mill. Average log size and minimum-sized log were also greater than commonly prevail at smaller mills.

The importance of obtaining cost and return figures applicable to medium-small mills has increased greatly within the last 10 years. In 1946, for example, 45 percent of the total pine production of East Texas came from mills cutting from 1 to 10 million board feet annually. For the lower South as a whole, 55 percent of pine production is from mills of this size class--mostly single, circular-headsaw mills cutting between 20 and 40 M feet per day.

This report is intended to supplement the Crossett study. It provides information, applicable to small or medium-sized mills cutting shortleaf-loblolly pine logs, concerning the effect of log diameter and quality on:

1. Lumber grade yields;
2. Production costs--per log and per M feet of rough, green lumber;
3. Net returns from the production of rough, green lumber.

1/ The authors wish to acknowledge the generous assistance of the J. E. Stone Lumber Company of Nacogdoches, Texas; the Southern Pine Inspection Bureau; and the Texas National Forests.

Effective use of these data requires a clear understanding of their limitations. The results were obtained from a limited log sample cut at a single, though representative, mill. They apply most directly to mills operating under similar conditions.

Wider application is possible if certain assumptions basic to this study are understood.

1. Mill costs are predicated on reasonably continuous, year-long operation. Fixed costs (fire insurance, taxes, interest, etc.) have been included with operating costs to arrive at a total cost per minute of headsaw time. These fixed costs will increase disproportionately with a decrease in operating time.

2. Costs are also based on an operating organization adjusted to a particular distribution of log sizes. Study results might not apply where differences in log size would require man-power or equipment changes.

3. The limitations of the log sample are discussed later (page 4).

In general, any radical change in methods of operation would make these findings inapplicable. The results show, however, the direction toward which both the mill operator and the grower may profitably direct their long-run efforts.

Conduct of Study

A complete record of size, quality, gross and net scale, sawing time, and lumber recovery was obtained for each study log. From these individual log records, averages could be calculated for any diameter or grade group.

Procedure

After the logs were measured, scaled, and graded in the mill yard, they were timed through the headsaw. Lumber was marked at the edger so that each board could be assigned correctly to the log from which it was cut. This marked lumber was graded on the green chain by a representative of the Southern Pine Inspection Bureau, and tallied separately for each log.

The logs were scaled by the Doyle, Scribner Decimal C, and International log rules. Standard Forest Service practice was followed in applying the last two rules. Application of the Doyle rule followed common East Texas practices: scaling diameter was taken to the nearest inch outside bark for all logs above 8 inches, and 8-inch and smaller logs were given their length as their scale.

An approximation of cubic volume was obtained separately for butt and upper logs. For upper logs, cubic volume was assumed to equal that of a cylinder having a diameter equal to the arithmetic average of the large and small end diameters of the log. Butt log cubic volume was taken as the volume of a cylinder with a diameter equal to the estimated mid-diameter. The nominal, not actual, length was taken for both upper and butt logs.

Cubic volume of lumber was obtained from the average actual thickness and width of boards (based on sample measurements) and their nominal length.

The logging cost data used in this report were adapted from the Crossett study (4). Details of this adaptation are given in the appendix, page 26.

Milling costs were based on company records for a full year's operation--from October 1, 1944, to October 1, 1945. This provided more reliable cost data than would be obtained from a short period in which costs might be distorted by unusual labor, maintenance, or seasonal conditions. For further discussion of costs, see appendix, page 31.

Lumber values are from the 1946 OPA prices for rough, green lumber.

Physical layout and operation of mill

The mill at which the study was made is fairly typical of medium-sized mills in East Texas. It cuts about 25,000 feet daily (Doyle log scale) of mixed pine and hardwood logs. The cut averages about 80 percent pine. Hardwoods were not included in the study. The mill has a 60-inch solid-tooth, circular headsaw, a 4-saw edger, 20-foot trimmer, shotgun feed, and manual setworks. Logs are turned by hand.

The 19-man mill crew was a little larger than average for mills of this type. Mills with mechanical log turners would normally have two less men on the mill deck. Some mills--particularly those which do not dip their lumber--might operate with one less than the four green chain pullers and sorters, since one man was required to straighten the lumber as it went through the dipping vat. The office and maintenance force consisted of seven men, including two company officers.

Normal cutting practices for mills of this size class were followed. A fair balance between "cutting for grade" and production speed was maintained. Small logs were generally cut into dimension stock--2 x 4's or 4 x 4's--or into one 4 x 4 in combination with any other standard size possible. While speed was stressed in cutting small logs, a definite effort was made to cut for grade on larger,

good-quality logs. In over-all efficiency, this mill is probably above the East Texas average.

The log sample

Selection of logs.--Logs were obtained from two national forest sale areas and from three private tracts. The logs were taken as they came from the log deck, selection being exercised only to secure the planned grade and diameter distribution. Plans called for about 30 logs of each log grade (see page 5 for log grades used) in each 2-inch diameter class. Some of the upper diameter and grade classes were never completely filled (table 1) because of a scarcity of logs in these classes.

The log sample studied does not represent either an average woods or mill run of logs. The study data are weighted in favor of grade 1 logs and logs of large diameter. This invalidates "average values" that might be calculated by combining data from the various diameter or grade groups. Where grade or diameter had no significant effect on a particular item, averages are perfectly valid and are presented in this report.

Table 1.--Distribution of log sample

Diameter class (inches)	Grade 1	Grade 2	Grade 3	All grades
	- -	Number of logs		- -
6	(1/)	(2/)	29	29
8	(1/)	30	31	61
10	16	35	36	87
12	19	31	35	85
14	17	34	32	83
16	12	18	25	55
18	8	9	14	31
20	2	5	7	14
22	0	1	5	6
24	0	0	2	2
28	0	1	0	1
Total	74	164	216	454

1/ Minimum diameter of grade 1 logs is 10 inches.
2/ Minimum diameter of grade 2 logs is 8 inches.

The study was designed to determine log values by log diameter and grade, and it is believed that the values given may properly be applied to most East Texas pine stands once the distribution of logs by diameter and grade has been determined.

Description of log sample

Shortleaf pine made up about 78 percent of the total sample and loblolly the remainder. Distribution of the two species was fairly uniform by grades, but there was more loblolly in the larger diameters. For the whole group, the ratio of shortleaf to loblolly is probably close to the natural distribution of these species in this region of East Texas. At any rate, the effect of species on lumber value is probably small. The Crossett study showed only a slight difference

(favoring shortleaf) in grade return between the two species, and in actual mill practice no distinction is made between them.

The proportion of butt logs was high in grade 1 and grade 2 and low in grade 3 (table 2). But this follows naturally from the application of the grade rules. Log grade usually, and log diameter always, decreases from the butt to the top of a tree, so that most grade 3 logs under 12 inches were from upper cuts.

Distribution of log lengths by diameter classes was reasonably uniform, and probably representative of the lengths to be found in mill-run East Texas pine logs. Sixteen-foot logs made up 72 percent of the total log sample. The average length in the different diameters and grades ranged from 15.7 to 17.3 feet. It is recognized that length is important when considering such facts as lumber yield and lumber value, and the data in this report should not be applied directly to a mill whose average log length is considerably more or less than 16 feet. For most East Texas mills, however, no correction for length should be necessary.

Table 2.--Distribution of log sample by log grade and position in tree

Grade	Butt	Middle	Top	Unknown	Total
	- - Percent of log sample - -				
1	89	11	0	0	100
2	69	20	2	9	100
3	35	21	12	32	100
All grades	56	19	6	19	100

Log grades

The basic log grading rules used were those developed by Reynolds at Crossett (see appendix, page 25). Two modifications of the Crossett system were made. Logs under 8 inches in diameter, excluded under the Crossett system, were included in this study. Grade 4 logs, which are essentially culls, were excluded. The grading rules as applied are as follows:

No. 1: Surface-clear logs 10 inches or over in diameter inside bark at small end, and logs over 16 inches d.i.b. with not more than three 2- to 4-inch knots; length, 10 feet or over.

No. 2: Logs 8 inches d.i.b. or over containing numerous small knots; or logs more than 14 inches d.i.b. containing four to six 2- to 4-inch knots; length, 10 feet or over.

No. 3: Knotty or crooked merchantable logs that do not fall in either No. 1 or No. 2 grade; length, 10 feet or over.

The Crossett rules, among several available, were chosen because they are easily applied, are relatively well known, and at Crossett proved reasonably accurate. Their use also facilitates comparisons between the current study and the Crossett study.

Results

Lumber recovery, overrun, and waste

Lumber recovery by log size and grade.--The actual amount of lumber cut from a log will differ considerably among mills. Mill efficiency, the type of equipment used, the thicknesses cut, and other factors contribute to this variability. Allowance for surfacing also varies at circular mills. The recovery shown here (figure 1) illustrates the effect of log diameter on lumber yield under conditions prevailing at the mill studied. Differences in lumber yield among the three log grades were insignificant.

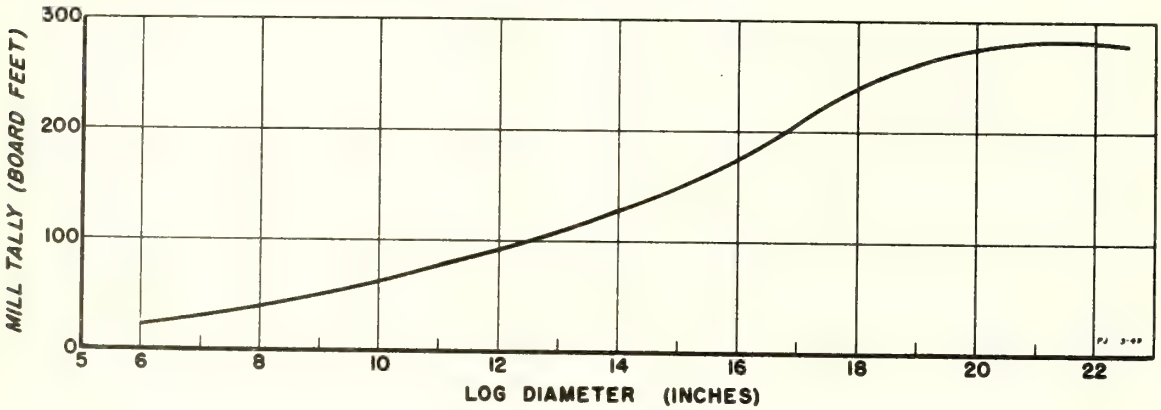


Figure 1.--Lumber production per log.

The lumber recovery curve (figure 1) begins to flatten out between 18 and 19 inches because logs above this diameter were simply too large to be handled efficiently at this mill. The point at which this occurs will vary among mills. Use of larger headsaws, a top saw, or "steam niggers"--or similar differences in equipment--would tend to move this point to a higher diameter. Use of lighter equipment would shift it to a smaller diameter. This should be borne in mind when applying the data to other mills.

Effect of log diameter and grade on overrun.--Overrun[2] from a log of a given size is affected by variations in application of the

2/ "Overrun" or "gain" is the excess of mill tally over log scale. "Underrun" is its opposite--the excess of log scale over mill tally. Though overrun can be expressed equally well in board feet, in this report the more usual practice of expressing it as a percent of the log scale concerned is followed. Only "rough green" mill tally is considered in this report.

log rule being considered and conditions influencing net lumber recovery. The more important of the factors that increase overrun are:

1. Reducing saw kerf;

2. Cutting thicker materials--e.g., 2-inch instead of 1-inch boards;

3. Cutting scant thicknesses;

4. Recovery of lumber grades which admit unsound material;

5. Utilization of narrow widths or short lengths from the swell or taper of the log;

6. Exceptional skill on the part of the sawyer;

7. Cutting for quantity rather than grade.

As these factors vary from mill to mill, so will the overrun under any log scale vary. The particular conditions existing at the study mill and their effect on overrun are discussed in the appendix, page 27.

For easy comparison, the overrun of the three log rules as they are most commonly applied (Doyle gross, and Scribner Decimal C and International $\frac{1}{4}$-inch net 3/) is given in figure 2.

The Doyle rule gave by far the greatest overrun in small logs--104 percent at 8 inches. This dropped rapidly, however, crossed the curve of Scribner overrun between 13 and 14 inches, and at about 20 inches became underrun. Because of the scaling practices followed for small logs, the Doyle overrun dropped rapidly for logs under 8 inches. Though the overrun from this rule is high, it would have been very much higher still if logs had been scaled inside bark (as for Scribner and International) and if log length had not been substituted for actual scale for logs below 8 inches in diameter.

Scribner Decimal C scale gave highest overrun at 8 inches and within the limits of the diameters studied gave no underrun. From its maximum at 8 inches (47 percent) overrun dropped rapidly to 25 percent at 11 inches, then continued a more gradual decline. The values in the Scribner Decimal C scale are rounded off to the nearest 10 feet for ease in recording and calculating. Over a large number of logs with average diameter range, the errors induced by this rounding average out, but for the smaller diameters they introduce a big variation in overrun. For example, 7- and 8-inch logs both scale 30 feet, yet the 8-inch log will yield much more lumber.

3/ Gross log scale is the total scale of the log. Net log scale is the gross log scale less the deductions made for defect (rot, sweep, splits, etc.).

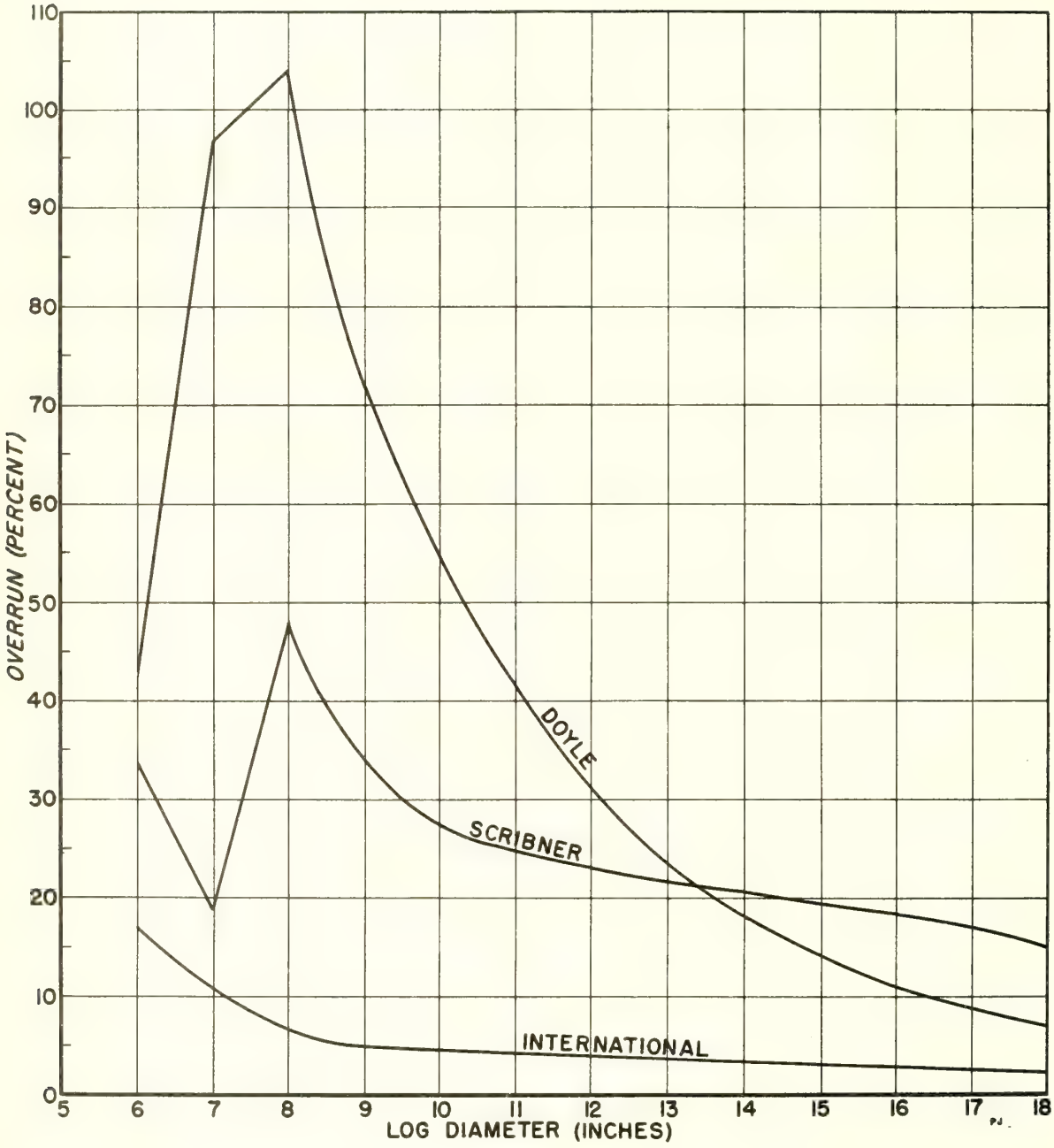


Figure 2.--Overrun: Doyle, Scribner Decimal C, and International $\frac{1}{4}$-inch log rules (Scribner and International net scale).

Overrun values from the International $\frac{1}{4}$-inch rule were by far the most consistent and were close to mill tally. The smallest logs (6-inch) did overrun 17 percent, but this dropped to only 5 percent at 9 inches and declined steadily to 2 percent at 20 inches.

A comparison between the overrun from gross and net log scales of both Scribner and International $\frac{1}{4}$-inch rules showed only a slightly greater deduction for defect under the Scribner than

under the International. Overrun on gross International scale, however, was less than zero from 9 inches and up, while overrun with gross Scribner fell to zero above 21 inches. Because of the small amount of defect (about 4 percent of gross log scale) and the fairly uniform distribution of defect by diameters, no separate analysis of the effect of defect on yields and values was considered necessary.

The ratio of cubic-foot recovery to total cubic log volume (figure 3) increased with increasing log diameter from only 54 percent at 6 inches to a maximum of 73 percent at 18 inches. Beyond this diameter, cubic-foot recovery fell off to less than 70 percent at 22 inches because of excessive waste in sawing.

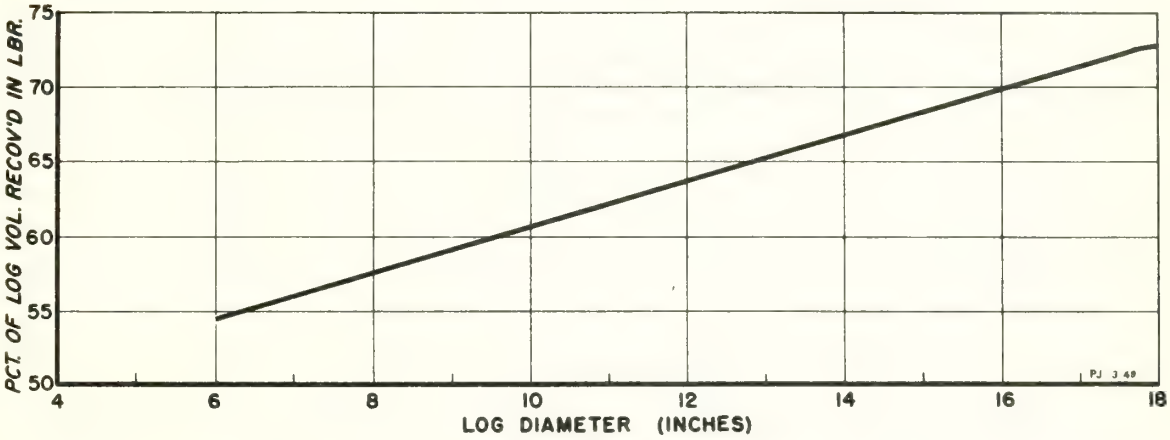


Figure 3.--Cubic-foot volume of lumber in percent of total cubic-foot log volume.

Waste.--Analysis of the records of total cubic content of study logs and of lumber recovered provided a basis for estimation of log volume wasted[4] in the manufacture of rough, green lumber (table 3).

The ratio of slabs and edgings to sawdust was calculated from the International log rule equations. A 5/16-inch kerf was assumed in these calculations. This method of determining kerf waste assumes cutting of 1-inch boards only, and makes no allowance for the wany-edged lumber frequently cut from small logs. Errors introduced by both causes are largest in the small diameter classes.

The conversion factor of 96 cubic feet per M feet of lumber was calculated from green chain measurements of thicknesses and widths.

4/ Waste as used here means all wood other than lumber. It is recognized that much of this volume is actually used by many mills for fuel, moldings, etc.

Table 3.--Lumber recovery and waste by diameter classes

Diameter class (ins.)	Cubic 1/ volume per 16-ft. log	Utilized as lumber		Waste 2/							
				Per log		Percent gross volume			Per M b.m. lumber tally		
		Per 16-ft. log	Portion of gross vol.	Slabs & edgings	Kerf	Slabs & edgings	Kerf	Total	Slabs & edgings	Kerf	Total
	Cu.ft.	Cu.ft.	Pct.	Cu.ft.	Cu.ft.	Pct.	Pct.	Pct.	Cu.ft.	Cu.ft.	Cu.ft.
6	4.36	2.37	54.4	1.18	0.67	27.0	15.4	42.4	47.75	27.21	74.96
7	5.67	3.17	55.9	1.40	.91	24.7	16.0	40.7	42.39	27.68	70.07
8	7.15	4.10	57.3	1.62	1.19	22.7	16.6	39.3	37.87	27.86	65.73
9	8.82	5.20	59.0	1.83	1.50	20.8	17.0	37.8	33.71	27.63	61.34
10	10.64	6.44	60.5	2.02	1.83	19.0	17.2	36.2	30.18	27.26	57.44
11	12.66	7.85	62.0	2.21	2.18	17.5	17.2	34.7	27.04	26.69	53.73
12	14.83	9.42	63.5	2.38	2.54	16.0	17.2	33.2	24.25	25.94	50.19
13	17.19	11.19	65.1	2.52	2.91	14.7	16.9	31.6	21.63	24.97	46.60
14	19.72	13.15	66.7	2.64	3.27	13.4	16.6	30.0	19.30	23.88	43.18
15	22.42	15.32	68.3	2.74	3.63	12.2	16.2	28.4	17.20	22.72	39.92
16	25.30	17.66	69.8	2.83	3.98	11.2	15.7	26.9	15.38	21.62	37.00
17	28.36	20.22	71.3	2.89	4.31	10.2	15.2	25.4	13.74	20.46	34.20
18	31.58	22.99	72.8	2.93	4.62	9.3	14.6	23.9	12.25	19.27	31.52
19	34.99	25.37	72.5	3.19	5.28	9.1	15.1	24.2	12.06	19.98	32.04
20	38.57	27.46	71.2	3.59	6.24	9.3	16.2	25.5	12.55	21.83	34.38

1/ By Smalian's formula, allowing 2 inches of taper per 16 feet.
2/ Exclusive of defect, which averaged 3.3 percent of gross volume. The ratio of kerf to slabs and edgings was determined from International log rule equations, with kerf allowance of 5/16 inch, and 1-inch lumber production assumed.

Lumber grades and values

It is generally recognized that log quality directly affects lumber recovery values. Grading standards, such as those embodied in the Crossett rules, have been developed to evaluate this quality factor. But in spite of their demonstrated value in the classification of logs, they are seldom used in the South. As a shift from a seller's to a buyer's market occurs, however, log quality will receive increasing attention; and log grades which provide a reasonably accurate measure of log quality should find increasing acceptance among progressive timber growers and sawmill operators.

Log size also has an important bearing on the recovery value of logs. The increase in lumber volume with log size is obvious. In addition, there are less apparent effects of log size on the unit value of lumber produced, mainly through the grade and width of the lumber.

The value recovered from a given log is, of course, affected by mill equipment and efficiency, sawing techniques, general mill practice, and similar items. But at a given mill the two factors, log size and log quality, largely determine the value of the lumber produced.

The effect of log diameter on lumber grade.--Lumber grade was related to log size because, on the average, the lumber cut from the larger logs had a higher proportion of clear material. This relationship would hold for a group of logs, even though not classified by grade[5/]. Most significant was the effect of diameter within grade 1 logs (figure 4). The percentage of combined C and B and Better increased rapidly in the smaller diameters, and continued to increase moderately in grade 1 logs. No constant trend was evident in the larger diameters of log grades 2 and 3.

The proportions of dense grades did not follow the above pattern. In both log grades 1 and 2, the proportion of dense material decreased from over 40 percent of total log volume at 10 and 8 inches respectively, to about 20 percent at 14 inches. Though little dense material was cut from grade 3 logs, even here the proportion decreased with increasing diameter.

This is believed explained by the not unusual cutting practices of the mill. Small logs (6 to 10 inches) were usually cut into dimension and structural materials, and so are graded under density classifications rather than finish. But in sawing larger logs, the high-quality, high-value finish grades are cut from the outside of the log.

5/ It was not possible from this study to determine the effect of log diameter on lumber grade recovery independent of log grade.

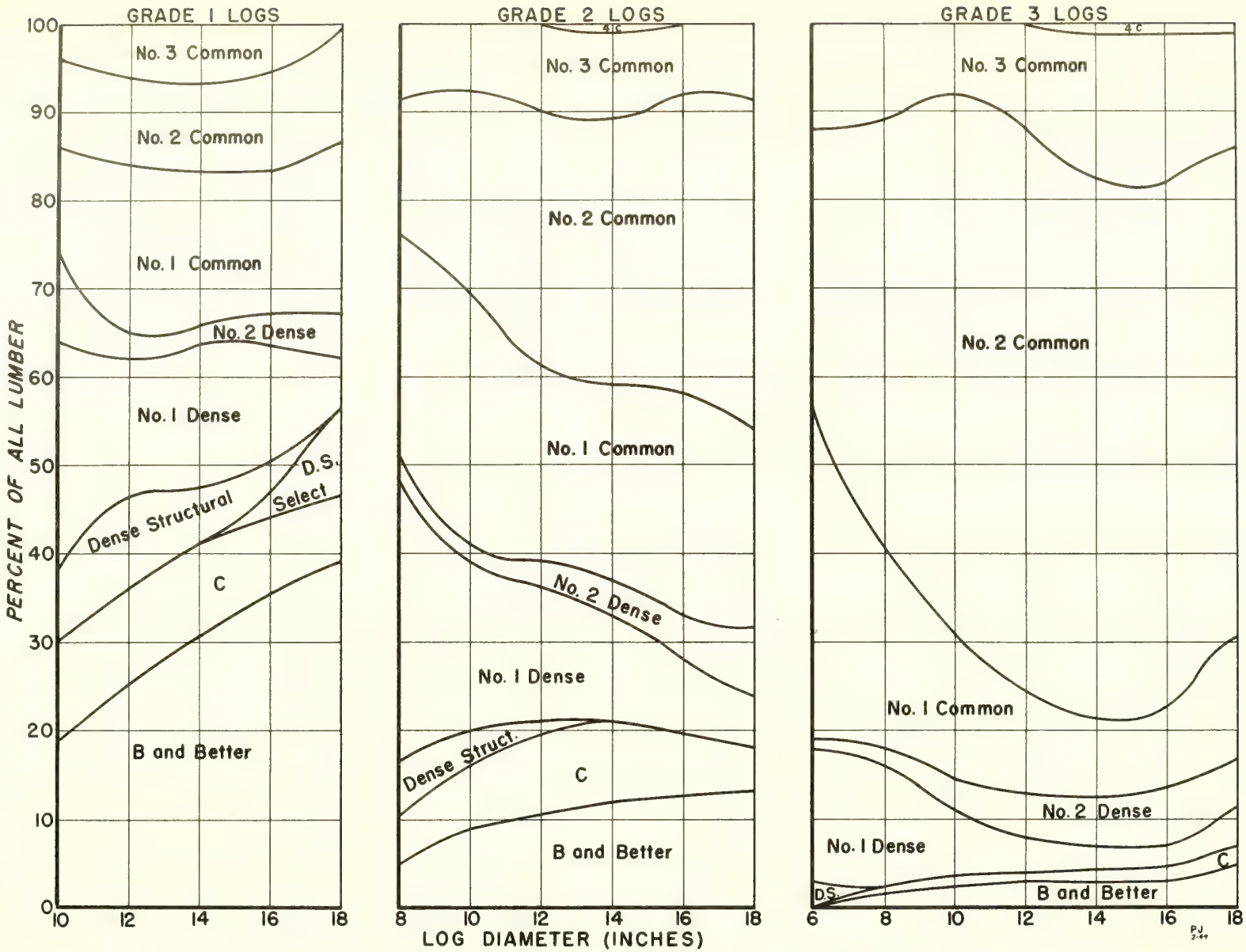


Figure 4.--Lumber grade recovery from grade 1, 2, and 3 logs.

Much of the interior portion will not produce structural material, so is cut into commons. The gradual decline in dense grade as diameter increases, and the corresponding increase of finish grades, is the result. Similar effects have been observed in other studies (3, 4).

Log size and lumber grade	Log grade 1	Log grade 2	Log grade 3
	- -	Percent	- -
10-inch logs:			
No. 1 Common and above	86	69	31
No. 2 Common and below	14	31	69
16-inch logs:			
No. 1 Common and above	83	58	23
No. 2 Common and below	17	42	77

The effect of log grade on lumber grade.--The effect of log grade on lumber grade recovery is readily apparent from figure 4. In percent of total lumber, the average yield of finish grades from 16-inch logs, for example, was 44 percent for grade 1, 20 percent for grade 2, and only 5 percent for grade 3 logs. If all the lumber were divided into just two grade groups--No. 1 Common and above and No. 2 Common and below--then the yield from 10- and 16-inch logs would be as shown above.

Lumber values.--The differences found in lumber grade yields are sharply reflected in the lumber values of various log grade-diameter groups.

Table 4.--Lumber value per log

Log diameter (inches)	Grade 1	Grade 2	Grade 3
	- -	Dollars	- -
6	...	...	0.85
7	...	...	1.15
8	...	1.61	1.48
9	...	2.03	1.85
10	2.81	2.57	2.33
11	3.48	3.16	2.85
12	4.24	3.83	3.41
13	5.13	4.60	4.08
14	6.17	5.49	4.86
15	7.42	6.51	5.84
16	8.86	7.67	6.96
17	10.69	9.14	8.36
18	12.53	10.54	9.71

Lumber values per log by diameter and log grade are shown in table 4. Grade 1 logs varied in lumber value from $2.81 for 10-inch logs to $12.53 for 18-inch logs. Grade 2 values rose from $1.61 at 8 inches to $10.54 at 18 inches. Grade 3 values rose from $0.85 at 6 inches to $9.71 at 18 inches.

Most of this increase in value with diameter was due to increase in volume. A part, however, resulted from an increase in the proportion of higher lumber grades recovered and from the wider widths produced from the larger logs. Almost $8 of the $8.93 increase from 8-inch to 18-inch grade 2 logs, for example, stems from the increase in volume; the rest of the increase is from the rise in value per M.

Average values per M feet of lumber produced further demonstrated the effect of log grade (figure 5). The three grades responded differently to increasing diameter--lumber from grade 2 and 3 logs increased only slightly in value per M, while grade 1 logs showed a substantial and more constant increase. Lumber from 10-inch grade 1 logs was worth $44.65 per M; from 10-inch grade 2 logs, $40.78; and from 10-inch grade 3 logs, $37.00. Lumber values per M from 18-inch logs showed a greater total spread--being $52.65, $44.30, and $40.80 for grades 1, 2, and 3, respectively.

Throughout this section on lumber grade yields and values, the data have been given in terms of log grades. A statistical check showed that in 19 times out of 20 a buyer purchasing a group of 400 or more logs could, by following these grading rules, predict the value per M board feet of the lumber to be produced with an error of less than 5 percent.

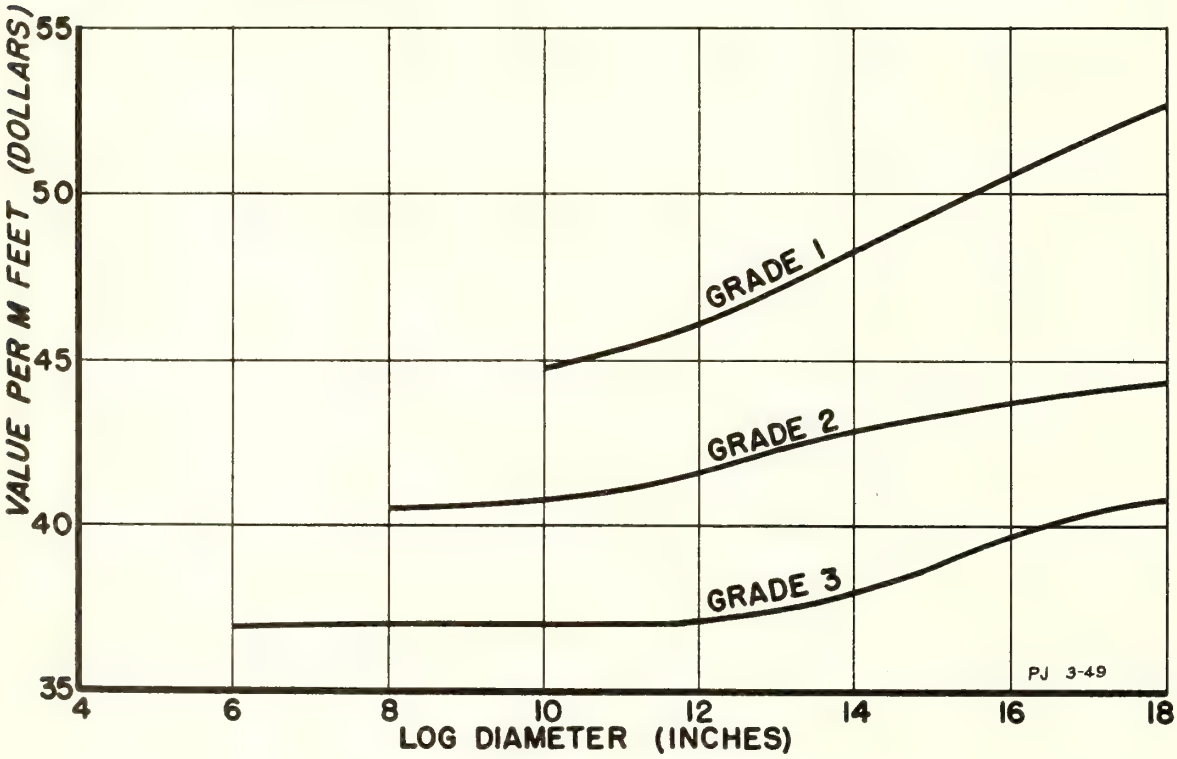


Figure 5.--Value of lumber recovered from logs of different grades.

Cost of production

To determine the per M cost of production by diameter classes, all costs were combined and a total cost per minute of headsaw time was calculated. Determination of the cost of milling any log or group of logs then became a matter of finding the time required to saw them.

To determine the per-minute cost of mill operation, all expenses incurred (see appendix, page 31) between October 1944 and

October 1945 were summed to give a total operating cost for the year. By taking costs over this long a period, the effects of any unusual expenses were minimized and most normal and seasonal fluctuations were included. The total operating time for this same period was next determined, and reduced by the delay percentage[6] calculated from study data. The total operating cost ($52,916.82) was then divided by the net operating time (2,087.22 hours) to give a net per-hour cost of $25.35, or a per-minute cost of $0.42255. This per-minute cost, when multiplied by the net sawing time in minutes, gave milling cost per log.

All milling costs were prorated according to headsaw time. The headsaw sets the pace for the entire mill, for as headsaw production decreases, men and machines throughout the mill must decrease their production. Their cost, however, remains essentially the same and must be charged against a smaller output.

Production costs and sawing time.--Though influenced by other factors, sawing time and cost are closely related to log volume (figure 6). Sawing time per M feet of lumber (figure 7) decreased from 23 minutes[7] (cost $9.65) for 6-inch logs to 12½ minutes (cost $5.28) for 18-inch logs. Beyond this point, unit cost and time increased rapidly. Most logs over 18 inches in diameter were just too large to be handled efficiently by the mill. The one 28-inch log included in the study took 53 minutes to saw. The log size handled at maximum mill efficiency (lowest cost per M) was about 18½ inches.

There was no significant difference in time or costs between logs of different grades.

Cost index.--To facilitate application of these findings to other mills like the one studied but having a different average log size, an "index of sawing costs" is given in table 5. Since the Doyle index is based on the overrun at the study mill, it will not give absolutely correct results for a mill having a different overrun or for one applying the Doyle rule in a different fashion. It does, however, provide a basis for determining sawing costs with reasonable accuracy.

To use this table, an operator must know the average diameter of the logs he cuts and the average sawing cost per M. Most operators will know the approximate average log diameter, but will probably have to calculate average sawing cost by dividing annual mill cost by the annual cut of the mill--either mill tally or Doyle log scale.

6/ During the study, delay time (saw changes, equipment breakdowns, rest periods, etc.) amounted to 13.68 percent of the total operating time. For a complete discussion of delay time, see appendix, page 30.

7/ The time the log was on the carriage excluding delays.

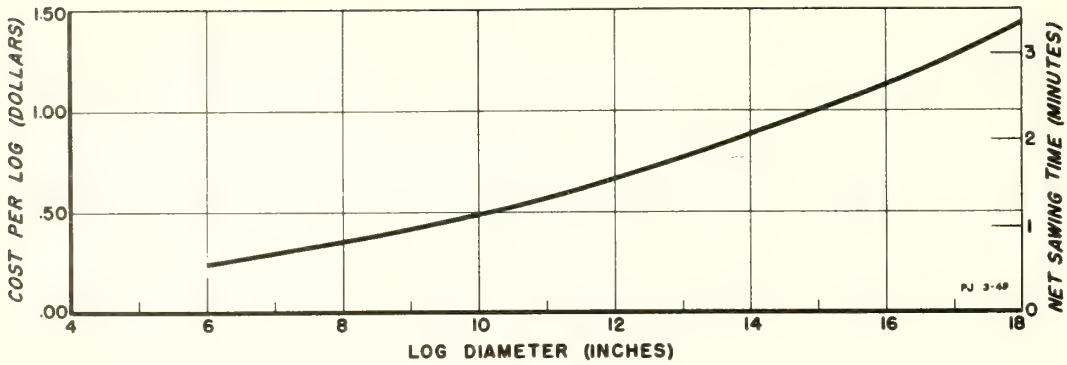


Figure 6.--Milling cost and net sawing time per log.

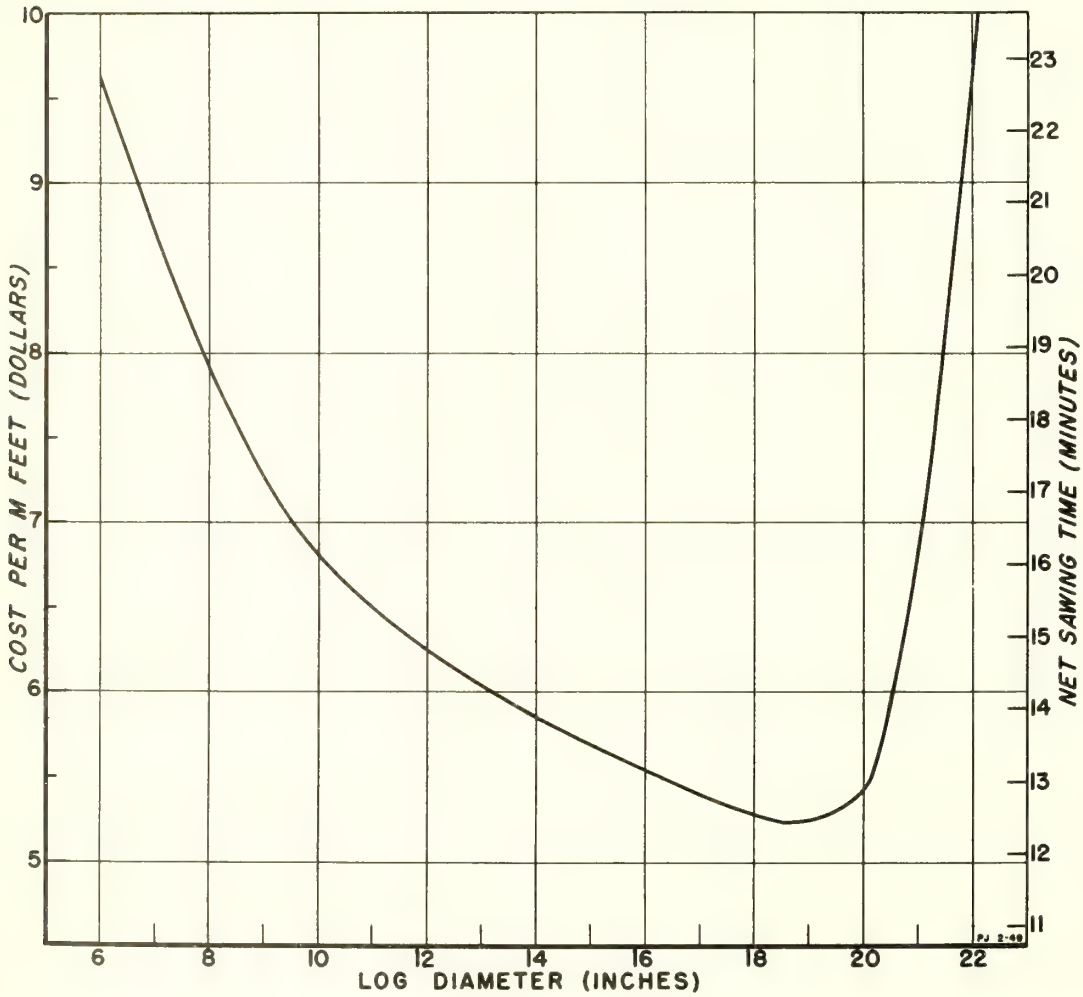


Figure 7.--Milling cost and net sawing time per M feet, mill tally (average of all log grades).

Table 5.--Sawing cost per M board feet, mill tally and Doyle log scale, in percent of cost of sawing the average-size log

Log diam. (ins.)	Mill Tally: Size of average log 9 inches	10 inches	11 inches	12 inches	Doyle Log Scale: Size of average log 9 inches	10 inches	11 inches	12 inches
6	132.5	141.0	147.9	154.1	111.1	131.4	150.4	169.3
7	120.4	128.1	134.4	140.0	137.9	163.1	186.6	210.0
8	108.9	115.9	121.6	126.7	129.4	153.0	175.1	197.1
9	100.0	106.4	111.7	116.3	100.0	118.3	135.3	152.3
10	93.9	100.0	104.9	109.3	84.5	100.0	114.4	128.8
11	89.5	95.3	100.0	104.2	73.9	87.4	100.0	112.6
12	86.0	91.5	96.0	100.0	65.6	77.6	88.8	100.0
13	83.2	88.6	92.9	96.8	59.9	70.8	81.0	91.2
14	80.7	85.9	90.2	93.9	55.6	65.7	75.2	84.6
15	78.4	83.4	87.6	91.2	52.2	61.7	70.6	79.5
16	76.3	81.2	85.2	88.8	49.4	58.4	66.8	75.2
17	74.3	79.1	82.9	86.4	47.2	55.8	63.8	71.8
18	72.5	77.2	81.0	84.3	45.2	53.4	61.1	68.8

By multiplying the average cost per M by the figures in the column closest to the average log diameter, the approximate cost per M for any diameter can be easily calculated. As an example: Suppose a mill has been cutting logs averaging 10 inches at an average cost of $11 per M, Doyle log scale, and the cost of sawing 8-inch logs is desired. Under the 10-inch Doyle column in table 5, opposite 8 inches is found 153. Multiplying the $11 average cost by this index of 153 percent gives $16.83--the cost of sawing 1,000 feet, Doyle scale, of 8-inch logs.

Realization values

Realization value is the "value" of some incomplete product, based on what could be "realized" from it by converting it to end products. Thus, the green-lumber realization value of logs on the sawmill deck (deck to green chain value) is the "value" of these logs that could be "realized" by sawing them into green lumber. Two realization values were calculated in this study: the deck to green chain value, and the stump to green chain value.

Table 6.--Realization value per log--deck to green chain

Diameter (inches)	Grade 1	Grade 2	Grade 3
	- -	Dollars	- -
6	...	...	0.60
7	...	...	.89
8	...	1.44	1.18
9	...	1.79	1.49
10	2.50	2.17	1.82
11	2.98	2.61	2.22
12	3.61	3.17	2.71
13	4.40	3.85	3.33
14	5.35	4.68	4.12
15	6.47	5.65	5.05
16	7.75	6.78	6.13
17	9.15	8.05	7.30
18	10.58	9.41	8.50

Deck to green chain.--Deck to green chain realization value is here computed as the difference between total sawmill cost, not including profit or risk allowances, from log deck to green chain and the value of rough, green lumber. It may be considered as the sawmill operator's margin to cover cost of logs at the mill plus profit and risk.

Realization value per log increased rapidly with increase in diameter (table 6). Not only was more lumber produced from the larger logs, but this lumber was worth more per unit and the sawing costs per M were lower. The difference between the three log grades is clear. For example, at 10 inches the realization value of grade 1 logs is $2.50 per log, for grade 2 logs $2.17, and for grade 3 logs $1.82. At 19 inches, the realization values per log for grades 1, 2, and 3 are $11.85, $10.48, and $9.48, respectively.

Realization values per M feet (figure 8) increased by diameter within all log grades because of an increase in lumber value per M and a decrease in milling cost per M. For example, the average realization value per M, mill tally, for 16-inch grade 1 logs was $45.08, while for grade 2 and 3 logs of the same diameter the mill tally realization values per M were $38.30 and $34.25, respectively.

This means that, in general, an operator who could afford to pay $15 per thousand, mill tally, for 16-inch grade 3 logs could actually make more money by paying $25 per thousand, mill tally, for 16-inch grade 1 logs. It is realized that logs are normally purchased by log scale--not by mill tally. But the particular log scale used and its application so affect the realization values through overrun

that presentation of results by log scale was not attempted here. Those who want deck to green chain realization value by log scale can obtain it with reasonable accuracy for their mill through multiplying the results in figure 8 by their own percentage overrun plus 100. One point, however, might be made here: If the overrun is high, the differences in realization value will also be high. For example, if overrun under the Doyle rule for 10-inch logs is 50 percent, then the difference in realization value between grades 1 and 3 will be roughly $7.50 x 150 percent, or $11.25 per M, Doyle log scale.

Stump to green chain.--Stump to green chain realization values (the margin remaining for stumpage, plus profit and risk for logging, transportation, and milling) may be calculated in several ways, each accurate for a particular sawmilling set-up. One extreme might be represented by a company which owns its own timber and conducts all phases of its logging on an hourly rate basis; the other by a company which buys all logs by Doyle log scale, delivered at the mill yard, or buys stumpage and contracts the logging, both on Doyle log scale. In this latter case, all costs prior to milling can be allocated on a log-scale basis regardless of diameter. Between these two extremes are many variations. No attempt was made to approximate green chain realization values for every possible variation, but the values under the two extremes were calculated.

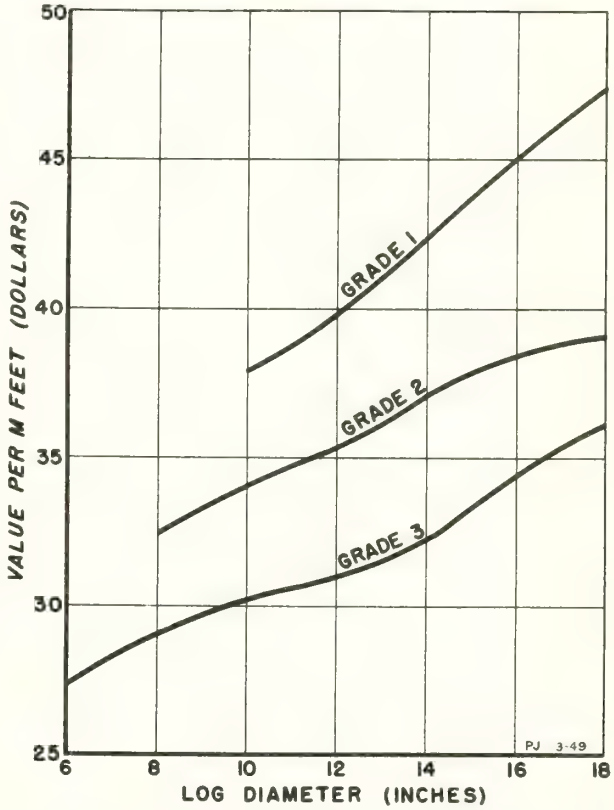
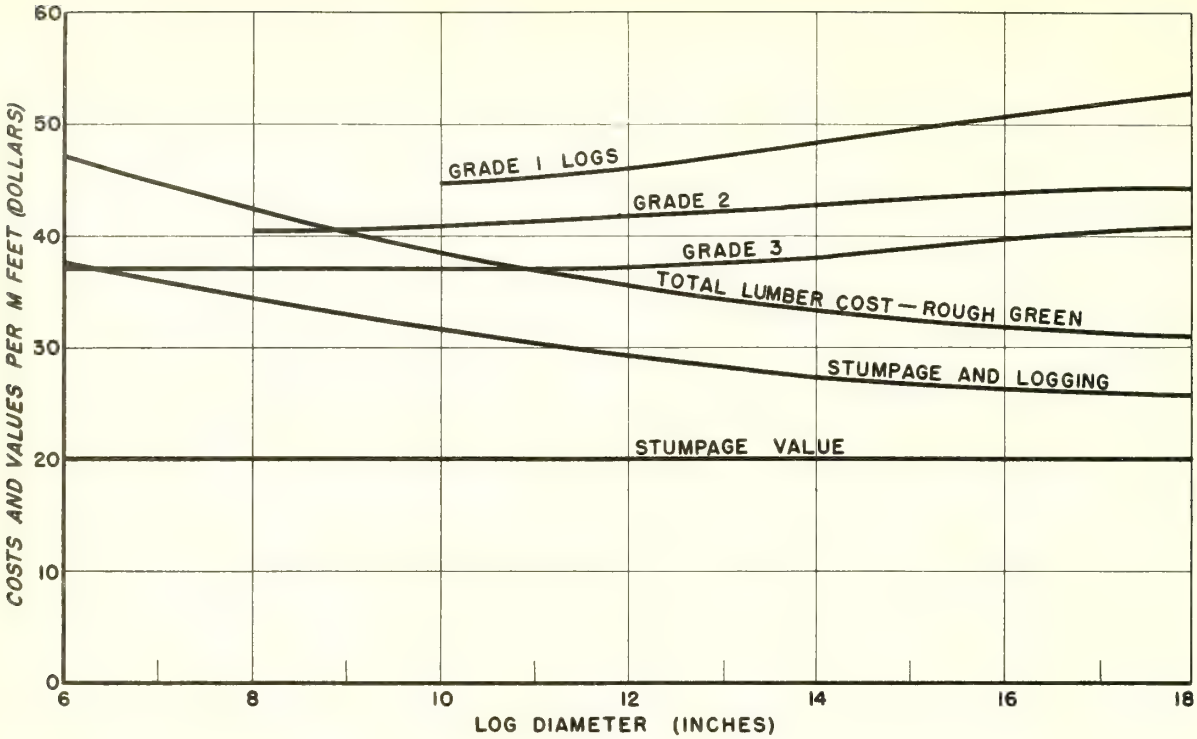


Figure 8.--Log deck to green chain realization values per M feet, mill tally.

FIRST EXAMPLE: In this instance, a company is assumed to own its own timber and conduct all phases of its logging on an hourly rate basis. A mill tally basis for all costs, including stumpage charges, is used to determine realization value. The effect of log grade and size is well demonstrated (figure 9, Top). With such a set-up, with stumpage valued at $20 per M, mill tally, all grade 3 logs below 11 inches in diameter are converted to lumber at a loss. Six-inch grade 3 logs show a net loss of $10.30 per M, mill tally. All grade 2



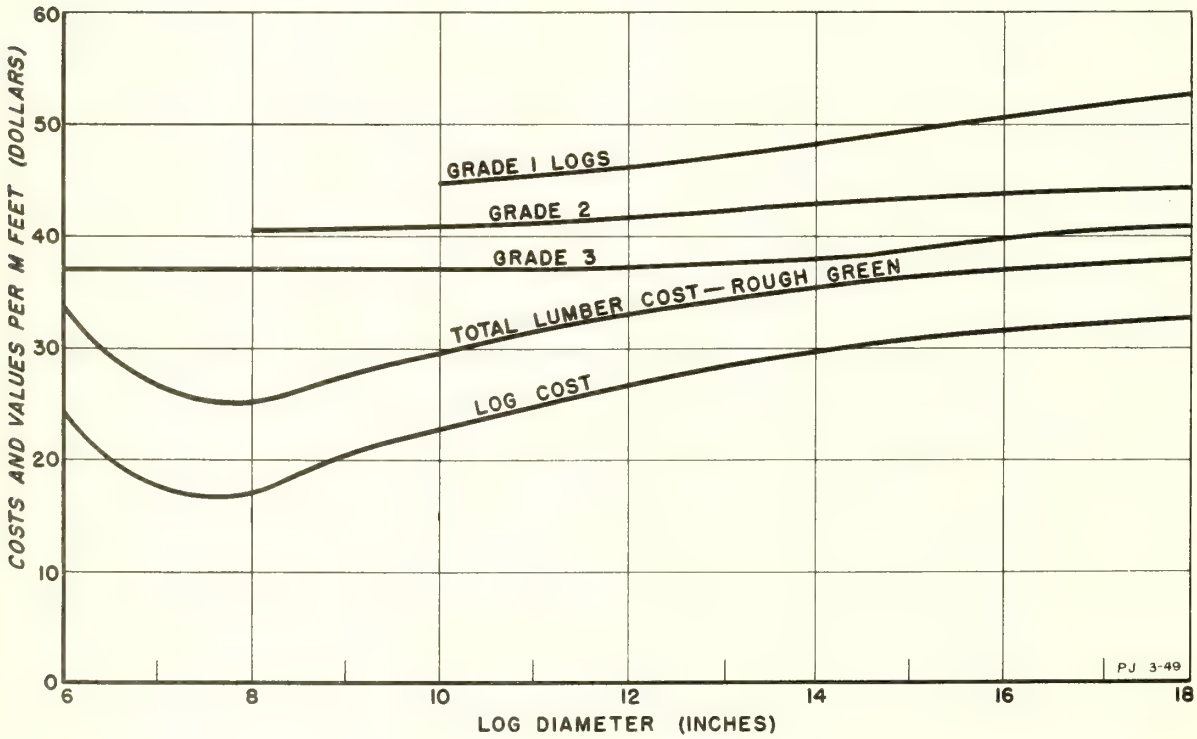


Figure 9.--Production costs and lumber values. Top, Mill owner's stumpage at $20 per M, mill tally. All costs and values on mill tally basis. Bottom, Logs purchased for $35 per M, Doyle scale, delivered at the mill. All costs and values on mill tally basis.

logs above 9 inches in diameter can be profitably converted, while the maximum margin remains from large grade 1 logs. The margin for all grades increases with diameter up to 18 inches.

SECOND EXAMPLE: This illustrates a condition at the opposite end of the scale, and one frequently occurring in East Texas. Here it is assumed that logs are purchased at $35 per M Doyle scale delivered at the mill yard--or stumpage is purchased at $20 per M Doyle scale, and logging is contracted at $15 per M Doyle scale for logs delivered to the mill. To facilitate comparisons between this and the first example, all costs have been converted from a Doyle to a mill tally base (figure 9, Bottom).

In this situation, the mill operator is not adversely affected by the greater cost of handling smaller logs up to the mill, since the logs are purchased at a given price per M Doyle scale, and because this scale gives a large overrun for small logs (104 percent at 8 inches). That is, from each thousand feet of 8-inch logs, Doyle scale, the operator is able to cut over 2,000 feet of lumber. The higher sawing cost entailed by the small log size is much more than offset by this overrun, and realization values may actually increase with decreasing log diameter. This was found true in the present example for grade 2 and 3 logs--in fact, the realization value of 8-inch grade 2 logs is nearly as high as that of large grade 1 logs. Given an unlimited market for material cut from 8-inch logs, the mill owner operating under this log procurement system might actually make maximum profit by cutting only the small sizes.

Comparison of these two log procurement systems indicates how mill owners may be subsidized by timber owners and logging contractors before the logs reach the mill. This may occur in nearly all phases of log procurement--from the sale of stumpage through felling and bucking, to loading and hauling. In many cases, some adjustment in stumpage price or contract logging costs is made to compensate for the deficiencies of the Doyle rule in measuring small logs. But in transactions of this kind the small timber owner and contractor are often at a disadvantage because they are less well informed regarding the true scale, or mill recovery from logs, than the mill operator.

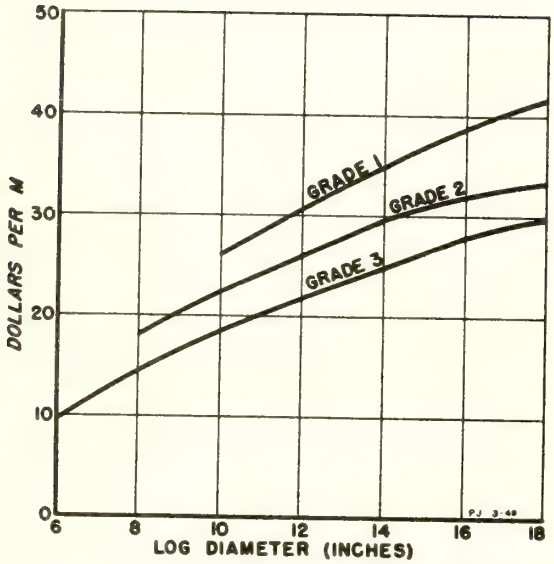


Figure 10.--Margin for stumpage, profit, and risk.

Stumpage values.--The arbitrary valuation of stumpage at $20 per M, mill tally, in the first example, though facilitating comparison between the two extremes, somewhat clouds the picture from the landowner's standpoint. The value of stumpage may be computed as that remaining after all costs of manufacture, including an allowance for profit and risk by each entrepreneur, have been subtracted from the final lumber value. The margin available for stumpage, profit, and risk is shown in figure 10. The rise from $9.60 at 6 inches to $29.75 at 18 inches for grade 3 logs demonstrates the effect of increasing diameter. The difference between log grades is equally apparent.

Summary

A study of shortleaf and loblolly pine log values and milling costs was made to determine the relationship of diameter and log grade to net lumber realization values at medium or small west Gulf mills. The study mill sawed daily about 25,000 feet of logs, Doyle log scale. It was equipped with a 60-inch solid-tooth headsaw, 4-saw edger, 20-foot trimmer, steam shotgun feed, and manual setworks. Logs were turned by hand. A total of 454 logs, ranging from 5 to 27 inches in diameter, were studied. Total mill tally of lumber produced was 50,540 board feet. All logs were graded by the Crossett log grading system.

1. Overrun varied as follows:

Doyle rule: from 104 percent at 8 inches to 7 percent at 18 inches.

Net Scribner Decimal C: from 47 percent at 8 inches to 15 percent at 18 inches.

Net International $\frac{1}{4}$-inch: from 7 percent at 8 inches to 2 percent at 18 inches.

2. Cubic-foot recovery varied from only 54 percent of total log volume at 6 inches up to 73 percent at 18 inches.

3. Lumber grade recovery from logs of each size-grade class was determined. For 16-inch logs, the yield of No. 1 Common and Better

lumber averaged 83 percent of the total yield from grade 1 logs, 58 percent from grade 2, and only 23 percent from grade 3.

4. Net sawing time per M feet varied from 23 minutes for 6-inch logs to 12½ minutes for 18-inch logs. Sawing time and cost per minute of operating time were used as a basis for determining green lumber production costs per log and per M feet. Cost did not vary significantly with log grade, but varied by diameter from $9.65 per M for 6-inch logs down to $5.28 per M for 18-inch logs. Production costs rose excessively for logs over 18 inches in diameter because of physical limitations of the mill.

5. Value per M feet of lumber (rough, green, OPA prices of May 1946) increased in all log grades with increasing diameter. The range in values was:

Grade 1: From $44.65 at 10 inches to $52.65 at 18 inches.

Grade 2: From $40.40 at 8 inches to $44.30 at 18 inches.

Grade 3: From $36.90 at 6 inches to $40.80 at 18 inches.

6. Log deck to green chain realization values--margin for stumpage, logging, profit, and risk--per M feet, mill tally, varied from $27.30 for 6-inch grade 3 logs to $47.40 for 18-inch grade 1 logs. The range by log grades was:

Grade 1: From $37.80 at 10 inches to $47.40 at 18 inches.

Grade 2: From $32.40 at 8 inches to $39.00 at 18 inches.

Grade 3: From $27.30 at 6 inches to $35.80 at 18 inches.

7. Stump to green chain realization values, determined by adapting Crossett study logging costs, varied greatly with different log rules and log procurement systems. At hourly wage rates for all labor and with stumpage valued at $20 per M, mill tally, all grade 3 logs under 11 inches in diameter were converted at a loss, while maximum realization occurred from the large grade 1 logs. For logs purchased at the mill by Doyle log scale, realization value was nearly as high for 8-inch grade 2 logs as for large grade 1 logs.

8. Index curves or tables for logging (see figure 11) and sawing costs (table 5) enable an operator with similar woods and mill equipment and practices to determine the effect of log diameter on costs for his operation--provided his average log diameter and average lumber production cost are obtainable.

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Appendix

Log grading rules used in study

The Crossett log grading rules, as defined by Reynolds, Bond, and Kirkland (4), were used. These rules are:

No. 1: Surface-clear logs 10 inches d.i.b. or over, and logs over 16 inches d.i.b. with not more than three 2- to 4-inch knots; length, 10 feet or over.

No. 2: Logs 8 inches d.i.b. or over containing numerous small knots; or logs more than 14 inches d.i.b. containing four to six 2- to 4-inch knots; length, 10 feet or over.

No. 3: Knotty or crooked merchantable logs 8 inches d.i.b. or over that do not fall in either No. 1 or No. 2 grade; length, 10 feet or over.

No. 4: Logs that are extremely crooked, or less than one-third sound.

According to these rules, grade 4 logs are essentially culls. Such logs are usually left in the woods. Very few grade 4 logs were brought into the study mill and none were included in the study. Merchantability standards for the small or medium-sized circular mill permit sawing of logs smaller than 8 inches d.i.b. For this reason, the 8-inch diameter limit in grade 3 logs was ignored during the present study.

Application of the log grades.--The log grades used are quite simple but require some judgment in their application. Distribution of knots, as well as number and size, should be considered. For example, a log over 16 inches d.i.b. would be classed as grade 1 even though it contained more than three 2- to 4-inch knots--provided they were all within a foot or so of the end of the log. Similarly, a log 14 inches or larger containing over six 2- to 4-inch knots would be classed as grade 2 if the knots were bunched or if they all occurred on one face.

In general, scaling defects do not affect the grade of a log. This is logical since they reduce the volume, not the quality, of the lumber produced. When defect becomes so serious that the quality of the remaining volume is affected, however, it does influence the log grade assigned. The following standards with respect to defect were followed in grading the study logs:

Sweep that reduced log volume but did not reduce percent of grade recovery was not considered in applying the grading rules.

Rot in logs, if affecting one-third or more of the log volume, automatically reduced the log one grade below that indicated by the surface characteristics.

Fire scar was not considered a defect unless over one-third of the log volume was affected. Logs with more than one-third of the volume involved in the scar were automatically reduced one grade below that indicated by the other surface characteristics.

Adaptation of logging costs

To obtain realization values covering all steps from stump to green chain, it was necessary to adapt logging costs from other studies. Crossett study data were used because logging conditions, equipment, and methods closely matched current East Texas conditions. The Crossett logging costs per M for logs in each diameter class, based on gross International $\frac{1}{4}$-inch rule, were converted to an East Texas mill tally basis by using the East Texas overrun of the gross International rule. This gave logging costs per M by log diameters on a mill tally basis accurate for the time at which the Crossett study was made.

The costs were brought up to date through use of index curves. These curves are based on the premise that though actual costs may have changed greatly, the relationship between logging costs and log diameters has remained reasonably constant (assuming similar logging conditions, methods, and equipment). The curves are constructed by setting the logging cost for some particular log diameter as 100 percent, then calculating the cost for other diameters as a percent of the selected one. From these curves, if the average logging cost per M for any log diameter is known, the costs per M for all other diameters can be calculated.

In East Texas, the pine logs now being sawed average about 11 inches in diameter inside bark (volume of about 60 feet, Doyle scale), and the average logging cost runs about $15 per M, Doyle scale. With these facts at hand, and the Crossett logging costs converted to the East Texas mill tally basis, we were able to adapt the Crossett costs through the following steps:

1. Mill tally logging costs were converted to a Doyle basis by using the East Texas Doyle overrun figures.

2. Index curves were constructed from these converted logging costs--one for mill tally, the other for Doyle--using the cost of 11-inch logs as a base.

3. Logging costs per M feet Doyle were then obtained by multiplying these index figures by $15--the estimated present-day cost of logging in East Texas.

4. Similarly, logging costs by diameters on a mill tally basis were obtained by multiplying the mill tally cost index figures by $10.58--the estimated cost converted to a mill tally base.

Since the Crossett study included no logs less than 8 inches in diameter, it was necessary to extend these data. These extended values are shown in figure 11.

Factors affecting overrun

The more important of the factors affecting overrun or underrun are discussed below.

Reducing kerf and cutting thicker materials.--Both the Scribner Decimal C and International $\frac{1}{4}$-inch log rules are based on a $\frac{1}{4}$-inch saw kerf. The saw kerf at the study mill was 5/16 inch. Overrun, therefore, was decreased because of the extra 1/16-inch kerf.

An analysis of the distribution of the lumber cut by thicknesses was also made. The increase found in the proportion of 1-inch lumber cut from the large diameters reflects the common practice of cutting large logs for grade. Large smooth logs, even though dense, will yield the highest value when cut into finish grades of lumber. This practice, together with that of cutting small logs into dimension, further increases the overrun of the small diameters, since both the Scribner and International rules are based on yields of 1-inch boards.

To determine roughly the effect of these two factors on overrun by log scale, an adjustment was made on the net scale by Scribner and International log rules. To adjust for kerf, the log scale was reduced by 0.045 percent--the difference between the International $\frac{1}{4}$-inch and 5/16-inch rules. The overrun from this adjusted scale is, of course, higher than from the normal scale (figures 12 and 13).

The adjusted log scale was next increased according to the amount of lumber cut in each thickness class. Though somewhat arbitrary, the following percentages represent approximately the savings due to thicknesses cut:

4-inch lumber	20 percent was added to log scale;
3-inch lumber	18 percent was added to log scale;
2-inch lumber	13 percent was added to log scale.

The overrun resulting from this adjusted (figures 12 and 13) log scale is believed to be a fair approximation of the overrun that might be expected if a $\frac{1}{4}$-inch kerf had been cut and only 1-inch lumber produced.

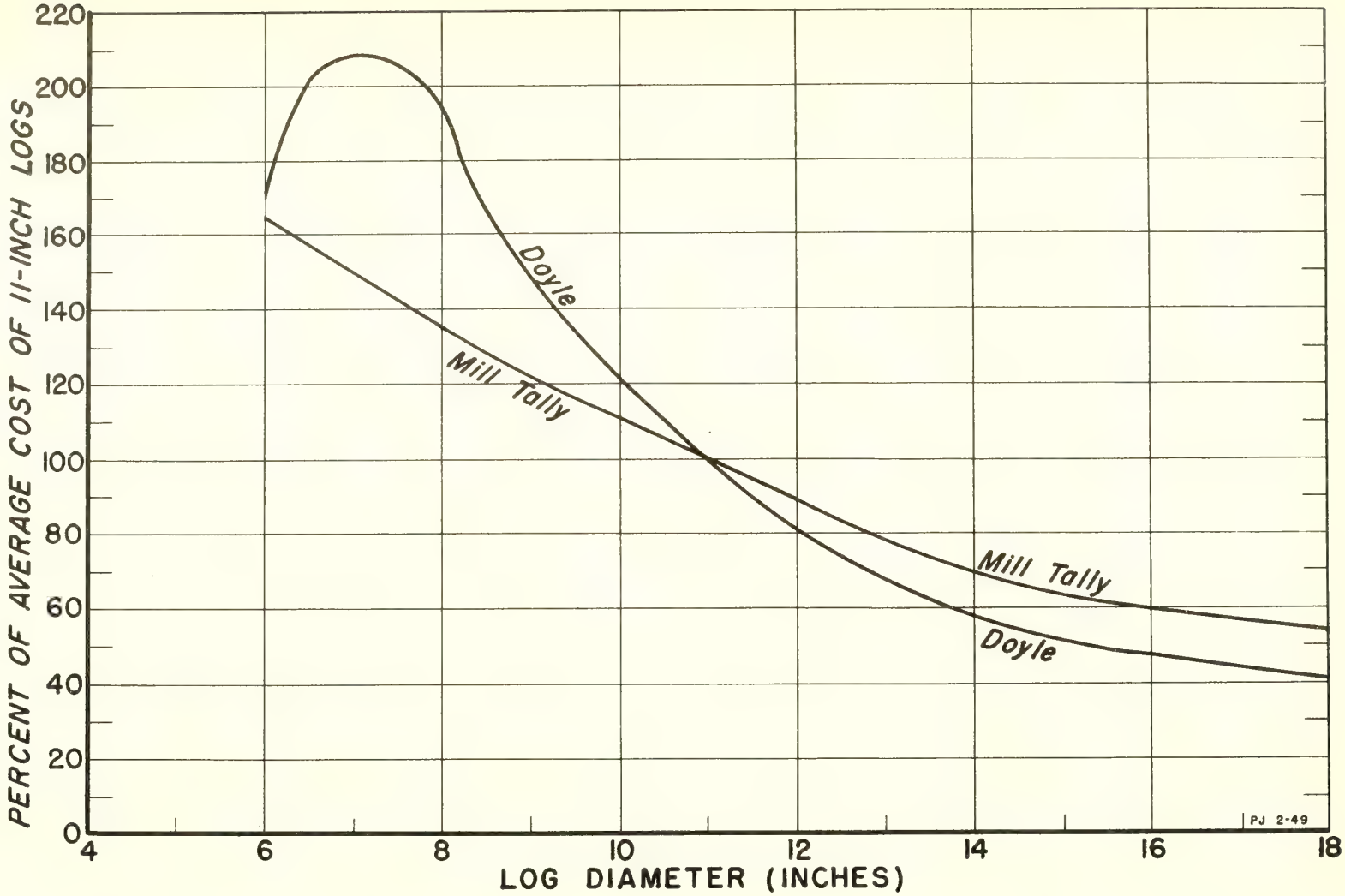

Figure 11.--Index curves of logging costs--Doyle rule and mill tally.

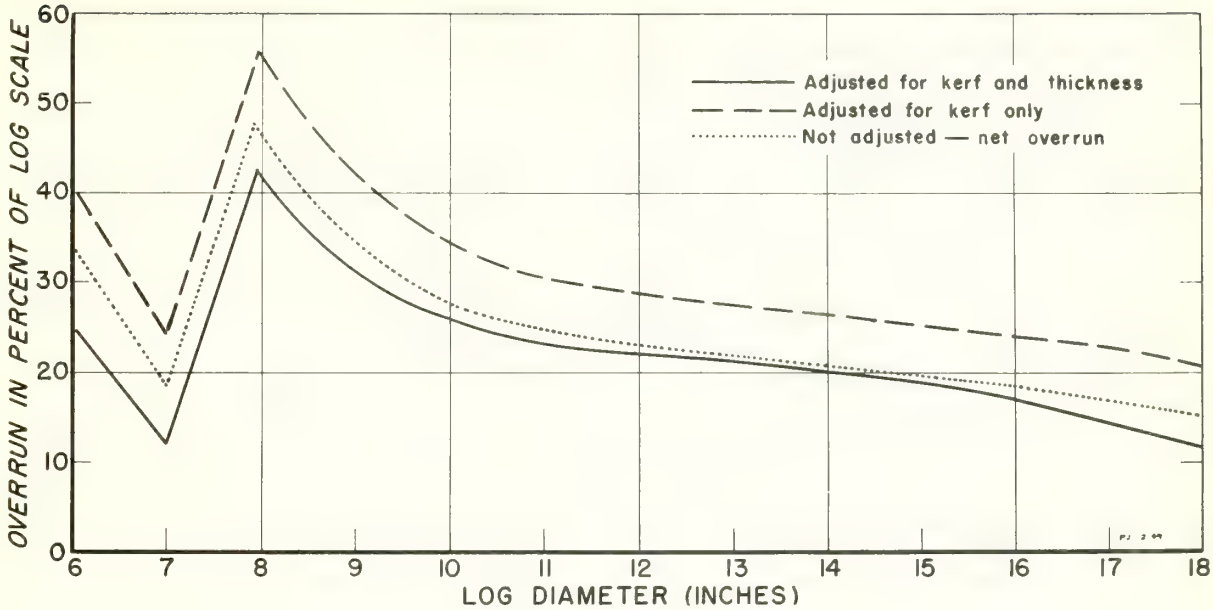

Figure 12.--Overrun from Scribner Decimal C log rule, showing adjustments for kerf and thicknesses cut.

Cutting scant thicknesses.--Thickness of the lumber cut was checked on the green chain throughout the study. It was fully up to, or perhaps slightly above, the thickness standards for rough, green lumber set by the Southern Pine Inspection Bureau.

Utilization of lumber grades which admit unsound material.--All lumber was graded under Southern Pine Inspection Bureau grade rules. The following grades were recognized:

B and Better	No. 4 Common
C	Dense Select Structural
No. 1 Common and Dimension	Dense Structural
No. 2 Common and Dimension	No. 1 Dense
No. 3 Common and Dimension	No. 2 Dense (1050 F).

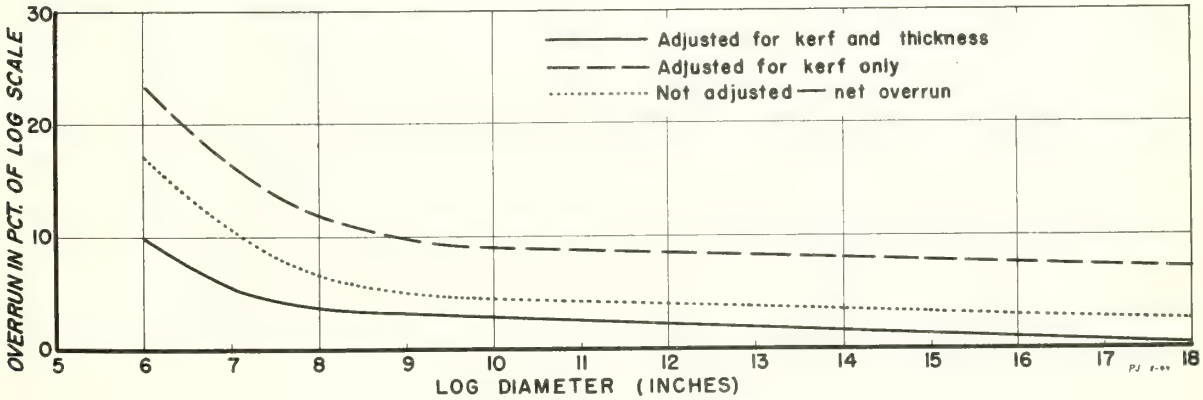

Figure 13.--Overrun from International 1/4-inch log rule, showing adjustments for kerf and thicknesses cut.

No. 3 and No. 4 Common permit inclusion of considerable defective material.

Utilization of narrow widths, or short lengths.--All short lengths sawed by the mill were included in the mill tally. These "shorts" included pieces as small as 1 x 4's three feet long. To the extent that these shorts were obtained as a result of taper, they increased overrun.

Exceptional skill on the part of the sawyer.--The sawyer at the study mill was not considered exceptionally skillful, though he was probably better than the average.

Cutting for quantity rather than grade.--There seemed to be a fair balance between cutting for grade and high production rate. More effort was made to obtain maximum grade recovery from larger, high-quality logs than from small or poor-quality logs.

Delay time

Rather than charge each delay to the log on the carriage at the time, a complete record of all delay time was kept. This time was prorated according to the net headsaw time of any log or log group. Thus each log bears a share of the delay time proportional to its net sawing time.

The delays observed during the short study period are not necessarily representative of average mill operation, and delay time will vary considerably among mills. In the Crossett study, the delay, or ineffective, time was found to be 6.76 percent of the total time (4) while Lodewick, studying Douglas-fir log values in 1941, found a delay time of 12.6 percent (2). Both of these operations were in relatively large band mills, and the Crossett study was conducted before the war when mill equipment could be better maintained and labor was perhaps more efficient. These factors probably account for most of the differences observed. In the opinion of the mill manager, the study covered a period of normal operation and the delays recorded were probably close to the average for a year's operation.

A list of the types of delay encountered, and how they compare in magnitude, is shown in the following tabulation:

	Percent
Saw changes	22.6
Engine trouble	30.4
Labor rest periods	2.4
Lack of logs on the mill deck	2.8
Saw hitting nail in log	.6
Slab and conveyor chain trouble	28.1
Other mill equipment	13.1
Total	100.0

These delays constitute 13.68 percent of the total operating time observed, or 15.85 percent of the net operating time.

Summary of mill costs

A brief summary of total costs at the study mill over the 1-year period, October 1944 to October 1945, is presented below.

Labor		
Direct labor	$34,650.07	
Industrial and unemployment insurance	2,134.16	
Total		$36,784.23
Operating Expenses		
Sawmill:		
Oil supplies, small supplies, and repairs	$ 3,361.08	
Office:		
Supplies and salaries	5,021.35	
Utilities:		
Gas, electricity, water, telephone, and telegraph	1,454.16	
Professional services:		
Banking, auditing, and attorney	625.43	
Total operating expenses		$10,462.02
Taxes (State, county, city, and school)		204.50
Fire insurance		1,172.50
Depreciation on mill, office equipment, and furniture		2,543.57
Interest on investment and operating capital at 5 percent		1,750.00
Total cost		$52,916.82

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A GUIDE TO PROFITABLE TREE UTILIZATION

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A GUIDE TO PROFITABLE TREE UTILIZATION

By
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Southern Forest Experiment Station

In most of the southern pine region, each tree or portion of a tree can be sold for any one of several different products that vary widely in both value and production costs. Under these conditions, the forest manager strives to channel the various portions of his trees into those uses that will insure the greatest net return on the entire cut.

This report presents a guide for determining the most profitable products to take from a tree, once the decision has been made to cut the tree. Though the discussion is concerned with southern pine, the principles apply equally well to any tree species. Included as an appendix to the report are some data on conversion costs that may be used by southern pine managers in arriving at their utilization decisions.

The questions involved in determining the most profitable utilization of the tree are not particularly complex. Consideration of them does involve at the outset, however, recognition of the fact that fixed (overhead) costs play no part in the choice between alternate uses of the tree or its parts. With a little thought this fact may seem obvious, yet it can be and sometimes is overlooked. It is necessary, therefore, in developing a method for determining the most profitable utilization of the tree, to exclude fixed charges. This point can best be made by a simple, hypothetical illustration.

Paradox of the Expensive Profits

Lumber Company X operates a mill in the lower South and draws its entire cut of 10,000 M board feet of lumber annually from its own pine timberlands. Its fixed costs are $70,000, or $7 per M. Seventy percent of the cut comes from butt and middle logs having an average "realization value" of $40 per M. The other 30 percent comes from top logs with a negative realization value of $2 per M. These realization values are the difference between the selling price of the lumber and the total cost of logging, milling, and selling, including fixed costs prorated on a per-M basis. They represent the margin for stumpage, profit, and uninsured risks.

The annual net return on this operation is $274,000, or $27.40 per M board feet:

7,000 M at $40 per M	$280,000	
3,000 M at $ 2 per M loss	-6,000	
Net return	$274,000	($27.40 per M)

Feeling dissatisfied with this use of top logs, the company sells them to a pulpwood contractor for $3 per M in the woods, attached to the tree tops. This looks like a profitable arrangement --an opportunity to change a loss of $2 per M to a net return of $3 per M on 3,000 M. No effort is made to obtain timber to offset that diverted to pulpwood, and total production drops from 10,000 M board feet per year to 7,000 M.

At the end of the year, the company finds that in exchanging a $2 loss for a $3 gain it has reduced returns 60 cents per M on its entire cut. This paradox of expensive profits resulted from the fact that lowering mill output from 10,000 M to 7,000 M increased fixed costs from $7 per M to $10 per M ($70,000 divided by 7,000 M). Thus the average realization value for butt and middle logs has been reduced from $40 to $37 per M. The statement of net return stands as follows:

7,000 M at $37 per M	$259,000	
3,000 M at $ 3 per M	9,000	
	$268,000	($26.80 per M)

The method employed by the company to determine the best use of its logs was faulty because realization value is influenced by total output. What is needed is a method of determining best utilization that will give the correct answer irrespective of the total volume of production. Such a method is described below, and is termed the "method of conversion surplus."

Method of Conversion Surplus

In this method, each portion of a tree is assigned to that use which will yield the greatest surplus of sale value over the direct (variable) costs of conversion, exclusive of fixed charges. This difference will be referred to as "conversion surplus."

To illustrate, take an 18-inch southern pine tree 85 feet in total height and capable of being subdivided into five full 16-foot sections. This tree has been felled, and the question is to what use each of the five sections should be put. Some of them may be usable for sawlogs, some for other products, and still others may not be usable at all.

It will pay to buck out and utilize any section the return from which will at least cover the direct costs of conversion. 1/ Any such section will pay its way. Those sections that show a surplus above direct costs help defray fixed costs and increase profit. It follows that the most profitable use of a section will be that which yields the highest conversion surplus. 2/ The sale values, direct costs of conversion (excluding direct costs chargeable to the tree as a whole), and resulting conversion surpluses for each section of this tree are given in table 1 for two alternatives, lumber and pulpwood.

Table 1.--Best use of an 18-inch southern pine tree as determined by the method of conversion surplus, where lumber and pulpwood are the alternatives

16-foot section	Used for lumber			Used for pulpwood			Best use	
	Sale value 1/	Direct costs of conversion	Conversion surplus	Sale value 2/	Direct costs of conversion	Conversion surplus	Conversion surplus	Product
	Dollars							
Butt	14.50	7.00	7.50	3.35	1.75	1.60	7.50	lumber
2nd	8.75	5.00	3.75	2.65	1.50	1.15	3.75	lumber
3rd	6.00	4.00	2.00	2.10	1.25	.85	2.00	lumber
4th	3.25	3.50	-.25	1.75	1.00	.75	.75	pulpwood
5th	-	-	(3/)	.75	.80	-.05	-.05	cull

1/ Based on finished lumber prices f.o.b. cars at mill.
2/ Based on price of pulpwood f.o.b. cars.
3/ No need to calculate conversion surplus since zero surplus has already been passed at the fourth section.

1/ Cost of conversion is calculated as a total up to the stage in conversion to which sale value applies. Direct cost as distinguished from fixed cost includes those expenditures for labor, supplies, and the like which are directly chargeable to the log in question. Whether these direct costs will be incurred depends on whether the log is utilized. For a comprehensive discussion of the types of cost, see "Studies in the Economics of Overhead Costs," by J.M. Clark, Univ. of Chicago Press, 1923; and "Cost Behavior and Price Policy," by Conference on Price Research, National Bureau of Economic Research, New York, 1943.

The general principle that products, to be worth handling, must repay at least their direct costs of conversion has been applied to forest management problems by, among others, W. W. Ashe in "Adjustment of the Volume Removed in Selection Felling," Journal of Forestry 24: 862-873,1926; and D.M. Matthews in "Cost Control in the Logging Industry," McGraw-Hill, New York, 1942, pages 34-39.

2/ Of course, if operating facilities can be run to capacity on other sections that have a still higher conversion surplus, the section in question had best not be utilized in this operation.

It appears from table 1 that the best use of the first three sections is lumber and of the fourth section, pulpwood. The fifth section has a negative conversion surplus in both uses and should be left in the woods as cull.

Not included in the table are costs such as locating, marking, and felling the tree. These costs of harvesting are jointly incurred by all sections in the tree and must be charged to the tree as a whole. Prorating such joint costs among the sections of the tree may lead to error.

As an example, assume a 10-inch two-log pine tree whose logs have a total conversion surplus of $1.00. Eighty cents of this value is derived from the butt log and 20 cents from the top log. If the joint cost of 60 cents for marking and felling the tree is prorated to the logs either by number of logs (30 cents apiece) or by volume (36 cents to butt, 24 cents to top log), the top log has a negative conversion surplus and would appear to be a cull.

Such a conclusion would be erroneous. The total conversion surplus of this tree is the sum of the conversion surpluses of its logs ($1.00) minus the direct cost of marking and felling (60 cents), or 40 cents. The fact that this conversion surplus is positive indicates that the tree is worth felling. If the top log is culled, the total conversion surplus of the tree is reduced to 20 cents, which is another way of saying that the top log is worth taking.

Here, incidentally, it is seen that the method of conversion surplus may be used to segregate those trees that will not pay their own way. If the sum of the conversion surpluses of the logs in a tree does not equal or exceed the joint costs of harvesting, the tree is a cull.

Application of method to an integrated woods-mill operation

Using the method of conversion surplus as just developed for a single tree, the problem of Lumber Company X and the paradox of the expensive profits may now be resolved. An analysis of the prospective cut is made, with the trees separated into whatever classes are most useful--perhaps tree species, diameter, merchantable height, and log quality. In table 2 the analysis is made by tree-diameter class, with merchantable height and log quality averaged within each class.

For purposes of simplification, joint costs of marking and felling are charged to the butt log, and any negative surpluses so obtained are disregarded providing the tree as a whole has a positive conversion surplus. The table shows that when the entire harvest is sawn into lumber, 10-inch trees have a negative conversion surplus. Omitting top logs from consideration, however, leaves all sizes of trees with positive

Table 2.--Best use of southern pine trees by the X Lumber Company, as determined by the method of conversion surplus, where the alternatives are to manufacture lumber and to sell logs in the woods to a pulpwood contractor

Tree d.b.h. class (inches)	16-foot logs per tree	All logs--used for lumber				
		Volume	Sale value per M b.f.	Direct costs of conversion per M b.f.	Conversion surplus	
					Per M b.f.	Total
	Number	M b.f.	Dollars	Dollars	Dollars	Dollars
10	2	300	62.00	65	- 3.00	- 900
12	2	650	64.40	60	4.40	2,860
14	3	1,150	66.60	57	9.60	11,040
16	3	1,400	77.39	55	22.39	31,350
10-16						
18	3	1,750	89.57	53	36.57	64,000
20	3	2,000	90.45	50	40.45	80,900
22	3	1,500	96.67	45	51.67	77,500
24	3	1,250	101.80	40	61.80	77,250
18-24						
All classes		10,000				344,000

Tree d.b.h. class (inches)	16-foot logs per tree	All but top logs--used for lumber				
		Volume	Sale value per M b.f.	Direct costs of conversion per M b.f.	Conversion surplus	
					Per M b.f.	Total
	Number	M b.f.	Dollars	Dollars	Dollars	Dollars
10	2	180	68	63	5	900
12	2	390	71	57	14	5,460
14	3	730	73	55	18	13,140
16	3	950	86	53	33	31,350
10-16						
18	3	1,250	96	48	48	60,000
20	3	1,450	97	45	52	75,400
22	3	1,100	105	40	65	71,500
24	3	950	110	35	75	71,250
18-24						
All classes		7,000				329,000

Tree d.b.h. class (inches)	16-foot logs per tree	Top logs					
		Volume	Used for lumber				Sold as pulpwood--total conversion surplus at $3 per M b.f.
			Sale value per M b.f.	Direct costs of conversion per M b.f.	Conversion surplus		
					Per M b.f.	Total	
	Number	M b.f.	Dollars	Dollars	Dollars	Dollars	Dollars
10	2	120	55	70	- 15	- 1,800	360
12	2	260	58	68	- 10	- 2,600	780
14	3	420	60	65	- 5	- 2,100	1,260
16	3	450	63	63	0	0	1,350
10-16		1,250				- 6,500	3,750
18	3	500	64	56	8	4,000	1,500
20	3	550	65	55	10	5,500	1,650
22	3	400	65	50	15	6,000	1,200
24	3	300	65	45	20	6,000	900
18-24		1,750				21,500	5,250
All classes		3,000				15,000	9,000

(Agric.--Atlanta)

conversion surpluses. These surpluses are greater per M than the $3 received from the pulpwood contractor. Judgment indicates that, by themselves, middle logs of three-log trees have a conversion surplus for lumber greater than the contractor's price, and therefore need not be analyzed separately.

This narrows to top logs the search for material that has been diluting profits. Further analysis shows that top logs from 18-inch and larger trees have a favorable conversion surplus as lumber, but that top logs of smaller trees are better channeled into pulpwood. The best utilization therefore is:

7,000 M of butt and middle logs: lumber	$329,000	
1,750 M of top logs: lumber	21,500	
1,250 M of top logs: pulpwood	3,750	
Total conversion surplus	$354,250	
Fixed costs	-70,000	
Net return	$284,250	($28.42 per M)

Proper utilization thus increases net return by $10,250, since the return when all logs were taken for lumber was $274,000.

Even with reduced production at the sawmill, which increases the overhead burden on the remainder of the cut, the utilization decisions arrived at by the conversion-surplus method have increased the net return. In effect, producers can safely ignore overhead costs in reaching utilization decisions, for the conversion-surplus method invariably results in the greatest amount of money from a given cut of timber to be applied to fixed costs, stumpage, profit, and uninsured risks.

Correct application of the method insures that the diversified raw material cut from the forest will be put to alternative uses yielding the highest net return. Further, an analysis of operations by the conversion-surplus method, with log or tree grade used as one of the classifications, may also result in utilizing a greater length of the bole than is normally considered profitable. Such an analysis will also identify the smallest size and poorest quality of tree that may profitably be removed on its own merits in thinning and stand improvement.

The more precisely that material is identified--as the breaking down of trees or logs into diameter classes and into quality classes within a diameter class--the more accurate will be the determination of best utilization. If a large volume or value of timber is involved, it may pay to apply the analysis in as much detail as possible. The limits to which the analysis should go can be decided by weighing possible increases in conversion surplus against the expense of determining them.

Where use of the conversion-surplus method would reduce plant operation below capacity, the method may be employed to determine the price that may be paid on the open market for stumpage or logs to keep the mill running. If the buyer can get such timber for less than its conversion surplus to him, he can increase his total net return by purchasing it.

Needless to say, use of the method does not insure a net profit. Where profits are possible, it will point the way to the greatest profit. Otherwise it will merely insure that loss is minimized.

Application of method by non-manufacturing stumpage producers

The method of conversion surplus applies equally well to a forest business selling logs. An example is Company Y, operating 10,000 acres of mixed southern pine and hardwoods. The allowable yearly cut under management is 2,500 M of logs from trees 10 inches d.b.h. and larger. The fixed costs are $15,000 per year. The company's policy has been to cut and deliver logs to a sawmill rather than sell stumpage. Currently, $40 per M, Doyle rule, is being received for all logs delivered, regardless of size, species, or quality. The company has the alternative of selling pulpwood on cars for $12 per standard cord. Its problem is to determine which logs should be sold as sawlogs and which as pulpwood.

Using the method of conversion surplus, the company finds that 10-inch trees and the top logs from 12-inch to 16-inch trees, inclusive, should be cut into pulpwood. The remainder of the cut should be sold as sawlogs. The calculation is shown in table 3; judgment indicates that the middle logs are clearly best sold as sawlogs and need not be analyzed separately. Net return from this system of utilization is:

10-inch trees: pulpwood	$ 1,640
Top logs from 12-inch through 16-inch trees: pulpwood	3,913
Remainder of crop: sawlogs	50,053
Total conversion surplus	$55,606
Fixed cost	-15,000
Net return	$40,606

This net return is more than $5,600 greater than that obtained from the current practice of putting everything into sawlogs, in which the total conversion surplus of $50,000 less fixed costs of $15,000 yields a net return of only $35,000.

In order to make these comparisons between sawlogs and pulpwood, it was necessary for Company Y to express all sale values in terms of

Table 3.--Best use of trees by Company Y as determined by method of conversion surplus, when the alternatives are to sell sawlogs at $40 per M bd. ft. Doyle or to sell pulpwood at $12 per standard cord

Tree d.b.h. class (inches)	16-foot logs per tree	All logs --sold as sawlogs			
		Volume	Direct costs of conversion per M bd. ft.	Conversion surplus	
				Per M bd. ft.	Total
	Number	M bd. ft.	Dollars	Dollars	Dollars
10	2	100	50	- 10	- 1,000
12	2	200	34	6	1,200
14	3	400	25	15	6,000
16	3	500	20	20	10,000
18	3	650	15	25	16,250
20	3	650	13	27	17,550
		2,500			50,000

Tree d.b.h. class (inches)	All but top logs							
	Volume	Sold as sawlogs			Sold as pulpwood			
		Direct costs of conversion per M board feet	Conversion surplus		Sale value per M bd. ft.	Direct costs of conversion per M board feet	Conversion surplus	
			Per M bd. ft.	Total			Per M bd. ft.	Total
	M bd.ft.	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
10	50	35	5	250.00	56.40	37.60	18.80	940.00
12	138	30	10	1,380.00	36.00	27.00	9.00	1,242.00
14	328	22	18	5,904.00				
16	390	17	23	8,970.00				
18	500	13	27	13,500.00				
20	514	11	29	14,906.00				
	1,920			44,910.00				

Tree d.b.h. class (inches)	Top logs							
	Volume	Sold as sawlogs			Sold as pulpwood			
		Direct costs of conversion per M board feet	Conversion surplus		Sale value per M bd. ft.	Direct costs of conversion per M board feet	Conversion surplus	
			Per M bd. ft.	Total			Per M bd. ft.	Total
	M bd.ft.	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars	Dollars
10	50	65.00	- 25.00	-1,250.00	42.00	28.00	14.00	700.00
12	62	42.90	- 2.90	- 179.80	60.00	40.00	20.00	1,240.00
14	72	38.67	1.33	95.76	66.00	44.00	22.00	1,584.00
16	110	30.63	9.37	1,030.70	39.60	29.70	9.90	1,089.00
18	150	21.67	18.33	2,749.50	37.20	27.90	9.30	1,395.00
20	136	20.56	19.44	2,643.84	36.00	27.00	9.00	1,224.00
	580			5,090.00				7,232.00

(Agric.--Atlanta)

a common unit of measure. As was seen in table 3, the company used M board feet, Doyle rule, for this purpose.

Use of Conversion-Surplus Method in the Woods

The illustrations given for Company X and Company Y show that it is not necessary to consider fixed costs in determining the utilization that will yield maximum net return. This point was most easily demonstrated by dealing with average trees so as to be able to pass over the variability of trees in height and quality within each d.b.h. class. A similar approach (using average trees) would be useful for any operator who wanted to map out a utilization policy and predict its effect upon his net return.

In using the method in the woods, however, the forest manager would take a somewhat different approach. He would compute the conversion surpluses (say for sawlogs and pulpwood) of individual logs of each diameter and grade. From these conversion surpluses he would determine the breaking points between sawlog and pulpwood use in terms of diameter within each grade. He would also locate the breaking points between pulpwood and cull.

Having established these points, the forest manager would give them to his woods foreman for use in guiding the logging. For many operators, such a determination of breaking points for individual logs would satisfy the entire need for utilization analysis.

Other Applications of Conversion-Surplus Method

The same principles as illustrated above for sawlogs and pulpwood apply where veneer, poles, piling, or any other products are included among the alternatives.

Sawmilling companies frequently have to decide between selling their high-grade trees to pole and piling producers and others or sawing them into the long, wide, high-grade boards that help to move a cut of lumber on the market. The method of conversion surplus applies to such problems. Tree diameter classes can be broken down into quality classes on the basis of log grades and assigned values that recognize the true worth of high-grade material. The trees that can more profitably be sold than sawn into lumber can then be determined by comparing their conversion surpluses.

In applying the conversion surplus method to stumpage purchased on a log-scale basis, the purchaser should handle the stumpage price as a direct cost. But if he buys, for a lump sum, either marked timber or timber to a diameter limit, the purchase price can be ignored in determining the most profitable tree utilization. The purchase price in these two instances is a cost covering the entire operation and must

not be allocated to individual logs or even to individual trees. It is therefore regarded as a fixed cost, not as a direct cost.

An interesting corollary to this analysis occurs where stumpage is sold on a log-scale basis for a fixed price per unit of measure. Such a price, added to the other direct costs of production, lends a negative conversion surplus to a portion of the material in felled trees that might otherwise be used to the advantage of both seller and buyer. Either the lump-sum sale or the log-scale transaction with prices adjusted for log size and quality may escape this disadvantage.

Appendix: Cost Data for Southern Pine

The method of conversion surplus as presented in this paper calls for the use of data on direct (as distinguished from fixed) costs of conversion. Such data are scarce for southern pine and almost nonexistent for other southern species. Some of the available data on direct costs of producing loblolly and shortleaf pine lumber and pulpwood are assembled here. The derivation of these data is explained in some detail so that they may, if necessary, be adapted to different conditions from those to which they directly apply.

The chief item in direct cost of timber conversion is labor, and this factor is therefore given primary emphasis in the following tables. Labor cost is expressed in man-hours, so that any hourly rate may be used to arrive at a dollar cost. Unfortunately the source data do not permit a separation of labor requirements in felling from those in bucking and limbing.

Items of direct cost other than labor are expressed in 1945 or 1946 dollars. They cover supplies and equipment directly consumed and chargeable to the material handled.

Pulpwood from small trees

Table 4 gives some data on direct costs of producing 5-foot pulpwood from pine trees 5 to 15 inches d.b.h., inclusive.

Table 4.--Direct costs per standard rough cord of producing pulpwood from southern pine trees

Tree d.b.h. (inches) (1)	Volume per tree (2)	Labor costs: Felling, bucking, limbing (3)	Labor costs: Loading, unloading (4)	Labor costs: Hauling (5)	Labor costs: Total stump to cars (6)	Costs other than labor (7)
	Cords	Man-hours				Dollars
5	.022	5.22	2.10	2.10	9.42	2.53
6	.038	4.58	1.80	2.10	8.48	2.53
7	.060	3.86	1.58	2.10	7.54	2.53
8	.095	3.36	1.41	2.10	6.87	2.53
9	.113	3.10	1.30	2.10	6.50	2.53
10	.135	2.97	1.25	2.10	6.32	2.53
11	.172	2.92	1.21	2.10	6.23	2.53
12	.204	2.92	1.19	2.10	6.21	2.53
13	.244	2.98	1.16	2.10	6.24	2.53
14	.283	3.06	1.15	2.10	6.31	2.53
15	.324	3.14	1.16	2.10	6.40	2.53

Columns 2 through 4 were adapted from Cuno (1),[1] columns 2 and 3 from his table 2, and column 4 from his table 7.

Column 5 was taken from Reynolds (4), table 4. Minutes per load were calculated for a 20-mile haul, stump to cars, as follows for the round trip:

	Minutes
2 miles of woods road at 11.35 minutes per mile	22.7
8 miles of graded dirt road at 3.95 minutes per mile	31.6
30 miles of gravel or hard road at 2.35 minutes per mile	70.5
40-mile round trip	124.8

Assuming 2 men accompanying a load and 1.98 cords per load, a requirement of 2.10 man-hours per cord was arrived at.

Column 7 covers direct costs other than labor--principally for gas, oil, tires, and the like consumed in hauling: other non-labor items are negligible. Cost per load was calculated first, from Reynolds (5), table 3:

	Dollars
2 miles of woods road at 20.5 cents per mile	0.410
38 miles of other road at 12.1 cents per mile	4.598
40-mile round trip	5.008

Cost per cord was then figured on the basis of 1.98 cords per load. This cost is in 1945 dollars.

Pulpwood from saw-timber tops

Where pine pulpwood is produced, not from entire trees, but from upper stems of sawlog trees, table 5 may be used. Here the material is segregated on the basis of small-end diameter, inside bark. The data were compiled on the basis of 16-foot sections taken from the tops of trees 10 through 24 inches d.b.h. and cut into 5-foot sticks.

1/ Underlined numbers in parentheses refer to sources listed at the end of this section.

Table 5.--Direct costs per standard rough cord of producing pulpwood from southern pine tops

Small-end diameter, i.b., of 16-foot section (inches)	Volume per 16-foot section	Labor costs				Costs other than labor
		Bucking, limbing, splitting	Loading, unloading	Hauling	Total, stump to cars	
(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Cords		Man-hours			Dollars
5	.038	2.11	1.70	2.10	5.91	2.53
6	.055	2.20	1.40	2.10	5.70	2.53
7	.061	2.39	1.25	2.10	5.74	2.53
8	.098	2.76	1.15	2.10	6.01	2.53
9	.120	3.52	1.13	2.10	6.75	2.53
10	.156	5.03	1.10	2.10	8.23	2.53
11	.195	7.80	1.10	2.10	11.00	2.53
12	.214	9.55	1.10	2.10	12.75	2.53

Column 3 was adapted from Reynolds, Bond, and Kirkland (6), table 39. Columns 4, 5, and 7 were taken from table 4 above, column 4 being adjusted on the basis of judgment.

Circular-Sawmill Operation

In table 6 are some direct-cost data covering the production of pine sawlogs and their conversion into rough green lumber at an efficient medium-size circular sawmill. This mill is equipped with edgers, trimmers, and dipping vats, and strikes a reasonable balance between cutting for volume and cutting for grade. The operation is traced from stump to green, dipped lumber loaded on trailers ready for hauling to the finishing plant. In order to make the data as useful as possible, they are shown for standard 16-foot logs of scaling diameters 6 through 18 inches. Quality is disregarded on the assumption that there is practically no difference in conversion costs between high- and low-quality logs of a given size.

Columns 2 through 5 were adapted from Reynolds, Bond, and Kirkland. Columns 2, 3, and 4 were adapted from their table 54, adjusted to per-log volumes reported by Gregory and Person (2), table 7 Column 5 (truck stand-by time) includes the driver's time during the locating of the set, loading, and unloading; the data were adapted from Reynolds, Bond, and Kirkland, table 60, again adjusted to per-log volume.

Table 6.--Direct costs per M board feet, green lumber tally, of producing southern pine sawlogs and lumber: circular sawmill operation

LABOR COSTS

Scaling diam. of 16-ft. log (inches)	Felling, bucking, limbing	Skidding	Truck loading	Truck stand-by time during loading	Truck hauling	Total, stump to log yard	Milling	Total, stump to lumber trailer
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Man-hours							
6	4.42	3.32	1.24	1.71	1.47	12.16	10.17	22.33
7	3.55	2.47	.92	1.48	1.44	9.86	8.72	18.58
8	2.98	1.91	.71	1.26	1.41	8.27	7.93	16.20
9	2.58	1.46	.54	1.04	1.37	6.99	7.33	14.32
10	2.29	1.15	.43	.84	1.33	6.04	6.83	12.87
11	2.26	1.00	.40	.74	1.31	5.71	6.51	12.22
12	2.05	.82	.33	.62	1.27	5.09	6.28	11.37
13	1.87	.68	.29	.53	1.23	4.60	6.05	10.65
14	1.73	.58	.25	.50	1.19	4.25	5.87	10.12
15	1.60	.50	.22	.47	1.15	3.94	5.73	9.67
16	1.51	.45	.20	.45	1.10	3.71	5.54	9.25
17	1.35	.38	.18	.42	1.04	3.37	5.41	8.78
18	1.25	.34	.16	.40	.98	3.13	5.33	8.46

COSTS OTHER THAN LABOR

Scaling diam. of 16-ft. log (inches)	Felling, bucking, limbing	Skidding, truck loading	Truck hauling	Total, stump to log yard	Milling	Total, stump to lumber trailer
(1)	(10)	(11)	(12)	(13)	(14)	(15)
	Dollars					
6	0.21	2.05	4.84	7.10	0.95	8.05
7	.17	1.53	4.82	6.52	.93	7.45
8	.14	1.18	4.80	6.12	.90	7.02
9	.12	.90	4.76	5.78	.87	6.65
10	.11	.71	4.68	5.50	.84	6.34
11	.11	.63	4.63	5.37	.81	6.18
12	.10	.52	4.54	5.16	.78	5.94
13	.09	.44	4.40	4.93	.75	5.68
14	.08	.37	4.26	4.71	.71	5.42
15	.08	.32	4.10	4.50	.68	5.18
16	.07	.29	3.90	4.26	.64	4.90
17	.06	.25	3.52	3.83	.61	4.44
18	.06	.22	3.12	3.40	.57	3.97

Column 6 (truck hauling) was computed from Reynolds (4), table 4, as follows for the round trip of 40 miles:

	Minutes
2 miles of woods road at 10.55 minutes per mile	21.1
8 miles of graded dirt road at 4.3 minutes per mile	34.4
30 miles of gravel or hard road at 2.25 minutes per mile	67.5
40-mile round trip	123.0

This figure of minutes per load was converted to man-hours on the assumption that only one man accompanies the load. Man-hours per load were converted to man-hours per M on the basis of Reynolds, Bond, and Kirkland, table 60.

Column 8 was adapted from Gregory and Person, table 23. Sawing time as given in this table was converted to man-hours on the basis of a working force of 22 men (Gregory and Person, page 5).

Columns 10 through 12, covering direct logging costs other than labor, are expressed in 1945 dollars. The data are taken from Reynolds (5). Column 10 is derived from the following items in his table 1, the costs being expressed in cents per two-man crew-hour:

	Cents
Supplies (oil, wedges, etc.)	3.3
Maintenance of saws and axes	6.3
Total	9.6

This factor was converted to a man-hour basis and multiplied by the figures in column 2. Column 11 was similarly derived from columns 3 and 4 and Reynolds' table 2. Column 12 is based on per-load costs given in Reynolds' table 4:

	Dollars
2 miles of woods road at 31.2 cents per mile	0.624
38 miles of other road at 17.5 cents per mile	6.650
40-mile round trip	7.274

Using conversion factors derived from Reynolds, Bond, and Kirkland, table 60, and Gregory and Person, table 7, this per-load cost was converted to a per-M basis for each log-scaling diameter.

Column 14 was adapted from Gregory and Person, table 22, and is expressed in 1945 dollars. The following were taken as items of direct cost:

	Dollars
Oil	544.80
Small supplies and repairs	2,816.28
Gas, electricity, and water	1,338.22
	4,699.30

This total direct cost per year was converted to cost per M by the use of 2,418 operating hours (Gregory and Person, page 30) and factors of time per M (table 23), to which was added 17 cents per M for stain preventive.

Band-sawmill operation

Some data on direct costs of producing pine sawlogs and converting them to finished lumber at a band mill are given in table 7. The sawmill is equipped with resaws, edgers, trimmers, and diversified finishing machinery, and an effort is made to get high lumber-grade recovery. The operation is traced from stump to finished lumber loaded on box cars. All costs are expressed per M board feet of finished lumber for 16-foot logs of scaling diameters 8 through 20 inches.

Columns 2 through 6 of table 7 were derived from the same sources as used for table 6, except that per-log volumes were taken from Reynolds, Bond, and Kirkland, table 28. This use of table 28, which is based upon unfinished lumber from logs of various lengths averaging shorter than 16 feet, was justified by the fact that the table's understatement of tally as applied to 16-foot logs is approximately equal to its overstatement of tally as applied to finished lumber.

Column 8 is adapted from Reynolds, Bond, and Kirkland, table 20, adjusted on the basis of per-log volumes from their table 28.

Column 9 is taken from Lowther and Murray (3, p. 949).

Columns 11 and 12 are based upon the same factors of cost per man-hour as used to derive columns 10 and 11 of table 6; these cost factors were multiplied by the man-hour data in columns 2 through 4 of table 7.

Column 13 was derived from the same sources as used for column 12 of table 6, except that per-log volumes were taken from Reynolds, Bond, and Kirkland, table 28.

Column 15 is based upon a 1946 average cost of $2.20 published by the Southern Pine Association (7, p. 4). This average cost was divided

Table 7.--Direct costs per M board feet, finished lumber tally, of producing southern pine sawlogs and lumber: band sawmill operation

LABOR COSTS

Scaling diam. of 16-ft. log (inches) (1)	Felling, bucking, limbing (2)	Skidding (3)	Truck loading (4)	Truck stand-by time during loading (5)	Truck hauling (6)	Total stump to log yard (7)	Milling (8)	Finishing, loading (9)	Total, stump to box cars (10)
	Man-hours								
8	2.65	1.70	0.64	1.12	1.26	7.37	4.57	15.40	27.34
9	2.72	1.53	.58	1.09	1.44	7.36	4.22	15.40	26.98
10	2.72	1.36	.52	1.00	1.58	7.18	4.00	15.40	26.58
11	2.70	1.19	.48	.88	1.56	6.81	3.76	15.40	25.97
12	2.56	1.03	.41	.77	1.59	6.36	3.58	15.40	25.34
13	2.39	.87	.37	.68	1.58	5.89	3.38	15.40	24.67
14	2.19	.74	.31	.63	1.51	5.38	3.21	15.40	23.99
15	2.01	.63	.28	.59	1.44	4.95	3.07	15.40	23.42
16	1.87	.55	.25	.56	1.36	4.59	2.98	15.40	22.97
17	1.73	.49	.23	.54	1.33	4.32	2.89	15.40	22.61
18	1.63	.45	.21	.52	1.27	4.08	2.82	15.40	22.30
19	1.58	.42	.20	.50	1.17	3.87	2.77	15.40	22.04
20	1.52	.40	.18	.46	1.08	3.64	2.73	15.40	21.77

COSTS OTHER THAN LABOR

Scaling diam. of 16-ft. log (inches) (1)	Felling, bucking, limbing (11)	Skidding, truck loading (12)	Truck hauling (13)	Total, stump to log yard (14)	Milling (15)	Finishing, (16)	Total, stump to box cars (17)
	Dollars						
8	0.13	1.06	4.79	5.98	2.80	1.72	10.50
9	.13	.95	4.77	5.85	2.62	1.72	10.19
10	.13	.84	4.74	5.71	2.51	1.72	9.94
11	.13	.75	4.70	5.58	2.39	1.72	9.69
12	.12	.65	4.64	5.41	2.30	1.72	9.43
13	.11	.56	4.56	5.23	2.20	1.72	9.15
14	.11	.47	4.46	5.04	2.12	1.72	8.88
15	.10	.41	4.33	4.84	2.05	1.72	8.61
16	.09	.36	4.18	4.63	2.00	1.72	8.35
17	.08	.33	3.99	4.40	1.95	1.72	8.07
18	.08	.30	3.76	4.14	1.92	1.72	7.78
19	.08	.28	3.30	3.66	1.89	1.72	7.27
20	.07	.27	3.12	3.46	1.87	1.72	7.05

into two parts. One part was assumed to vary directly with milling time per M. To handle this part, $1.70 was assigned to the average log (13 inches, as computed from Reynolds, Bond, and Kirkland, table 16), and amounts were assigned to logs of other diameters in proportion to the man-hour data in column 8. The second part of average cost, $0.50, was assumed to be constant per M. It was therefore added uniformly to each of the amounts arrived at above.

Column 16 is based upon 1946 data of the Southern Pine Association, page 4.

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AMOUNT OF CHIPPABLE WASTE

AT SOUTHERN PINE SAWMILLS

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AGRIC - ATLANTA

AMOUNT OF CHIPPABLE WASTE AT SOUTHERN PINE SAWMILLS

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This paper summarizes the results of a study of the amount of wood waste, suitable for pulp chips, produced at four different classes of southern pine sawmills. The study, carried out between October 1948 and February 1950, was made cooperatively by the Southern Kraft Division of the International Paper Company and the Southern Forest Experiment Station.

Study Methods

Results were obtained at 16 sawmills in northern Louisiana and in southern and central Arkansas. On the basis of their sawing equipment, the mills were divided into four classes:

Class 1	Band headsaw with resaw
Class 2	Solid-tooth circular headsaw with resaw and shotgun carriage feed
Class 3	Solid-tooth circular headsaw with steam feed (small gun); no resaw
Class 4	Portable mill with circular headsaw using inserted bits; no resaw

Two mills of each class were in Arkansas and two in Louisiana.

Most of the study logs were loblolly and shortleaf pine. At some of the mills, a few longleaf logs were included. All logs were peeled before sawing. Practically all of the logs came from second-growth timber, and the volume of heartwood was so small that it was included with the sapwood in computing the waste.

At each of the mills, an attempt was made to secure data on waste from the number of logs indicated in the tabulation at the right. Only one log was obtained in the two largest diameter groups. In the other diameter groups, it was not possible to get the desired number of logs at every mill, but enough were studied to assure statistically reliable results and to give a sound basis for comparisons between classes of mills.1/

Diameter group (inches)	Scaling diameters included	Logs desired
	Inches	Number
6	4.51 to 6.50	20
8	6.51 to 9.50	50
11	9.51 to 12.50	50
14	12.51 to 15.50	50
17	15.51 to 18.50	20
20	18.51 to 21.50	20
23	21.51 to 24.50	5
26	24.51 to 27.50	5
29	27.51 to 30.50	5

The procedure for determining the amount of waste was the same at each mill. Logs were peeled by hand and then segregated by diameter groups. For each log the average diameter was taken to the nearest 1/10 inch at the small end, middle, and large end. All diameter measurements were taken inside bark with calipers. Length was measured to the nearest 1/10 foot with a steel tape. Net Doyle scale, inside bark, was recorded. Logs were reduced in volume for sweep in excess of 2 inches and for rot, fire scars, and other deductible defect; and those under 8.5 inches in diameter were given a scale equal to their length. The volume in cords of waste per thousand board feet has not been adjusted to a base of 16-foot log length because the average log length of both the study logs and those found in a subsequent analysis of the annual log intake closely approached this figure.

The peeled logs in each diameter group were weighed to the nearest 5 pounds.

The logs were put through the sawmill by diameter groups and data were recorded separately for each group. A piece tally of the lumber by length, width, and thickness was made by the sawmill's lumber grader. Six samples of the green wood were taken at random from the sapwood portion of the lumber in each diameter group, and the moisture content was determined by the oven-dry method.

1/ Tables of the standard error and standard error in percent of the mean of the waste in cords by mill classes for Arkansas and Louisiana show fairly consistent results. For all mill classes, the greatest error is in the 8- and 11-inch diameter groups.

All slabs, edging strips, and end trim from each group were collected and weighed immediately after sawing. For at least two mills in each class, the waste was then sorted into chippable and non-chippable material. For the purposes of the cooperators, non-chippable material consisted of thin, ribbon-like pieces of edging strips and all heavier material less than one foot long. The amount of such material varied by diameter classes (see footnote to table 4, page 7) but averaged only 6 percent of the total heavy waste. Weight or volume of sawdust was not determined. The data on heavy waste were computed in terms of weight and then converted, taking 2,500 pounds of oven-dry wood as the equivalent of one cord.

This phase of the study gave the volume of waste for the study logs only. In order to determine the total volume of waste produced by the different study mills, it was necessary to determine the log intake pattern (by diameter and length) for the individual mills. This information was obtained from a study of each mill's log scale sheets for each tenth sawing day throughout the first half of 1948.

Amount of Waste

The amount of chippable waste produced per thousand board feet, green lumber tally, was 0.43 cord for class 1 mills, 0.46 cord for class 2 mills, and 0.61 cord for mills in classes 3 and 4. In 1948, the average study mill in class 1 or 2 cut about 8,000 M board feet of pine lumber, and thus produced about 3,500 cords of chippable waste. Class 3 study mills, with an average annual cut of 4,800 M board feet of pine, had 2,900 cords of heavy waste; and class 4 mills, with only half the lumber output of the class 1 mills, still produced over two-thirds as much waste. The volume of chippable waste for the study mills, as calculated from the 1948 log intake records, is shown in table 1.

Table 1.--Waste production at 16 study mills, 1948

Mill class	Lumber production	Chippable waste	Chippable waste per M b.f.
	M b.f. green lumber tally	Cords	Cords
1	32,465	13,992	0.43
2	31,949	14,601	.46
3	19,218	11,742	.61
4	15,836	9,676	.61

Table 1.--Southern bottomland forest types and their major characteristics

The types recognized here do not correspond to the standard types of the Society of American Foresters, because the standard types are more refined than is necessary or desirable for management purposes. (See Appendix for manner in which the Society of American Foresters types are combined in this report.) The most important or key species in each type are marked with an asterisk.

Type	Characteristic species	Occurrence by site	General features	Common variations in type
Sweetgum-water oaks	*Sweetgum *Water oak *Nuttall oak *Willow oak *Soft elm *Hackberry *Green ash Overcup oak Sweet pecan Bitter pecan Cedar elm Cottonwood Diamondleaf oak Laurel oak Red maple Honey locust Persimmon	General in first bottoms except deep sloughs, swamps, fronts, and poorest flat sites. Also on terrace flats.	Most widely distributed type. Second in quality, though nothing excels the best of this type. Produces high-value factory lumber and veneer logs.	(a) Predominantly sweetgum: on well-drained first bottom ridges and pervious silty clays on terrace flats. (b) Predominantly water oaks: on heavier soils on first bottom ridges and better drained flats; on poorly drained flats on terraces. Nuttall oak dominates on well-drained first bottom flats. Willow oak prevails on first bottom ridges and poorly drained terrace flats, i.e., pin oak flats; near the Coast laurel oak takes over. (c) Cedar elm-water oaks: on poorly drained, impervious soils on low or indistinct first bottom ridges. Of minor importance on impervious terrace soils.
White oaks-red oaks-other hardwoods	*Cow oak *White oak *Delta post oak *Cherrybark oak *Shumard oak *Southern red oak *White ash *Hickory *Black gum *Winged elm Sweetgum Overcup oak Willow oak Water oak Laurel oak Post oak Soft elm Magnolia Yellow-poplar Loblolly pine Spruce pine Beech	Best fine, sandy loam soils on first bottom ridges and all ridges on the terraces. Type extends on first bottom ridges to a few peculiar well-drained soils other than sandy loam.	Highest value type, with best species and highest quality products. Second only to sweetgum-water oaks type in area. Produces high-quality tight cooperage, factory lumber, veneer logs.	(a) Predominantly white oaks: on the most matured terrace soils. (b) Pine-hardwood: in very limited situations; most common with loblolly on terraces, but also with spruce on ridges in first bottoms of small streams of the Coastal Plains east of the Mississippi River.
Hackberry-elm-ash	*Hackberry *Soft elm *Green ash *Bitter pecan *Willow oak Cedar elm Overcup oak Sweet pecan Water oak Nuttall oak Winged elm White ash Cherrybark oak Blackgum Persimmon Red maple Boxelder	Low ridges, flats, and sloughs in first bottoms and terrace flats and sloughs. Occasionally on new land or fronts. Rarely on badly maltreated terrace ridges.	Temporary type following heavy cutting and fire or succeeding cottonwood. Widely distributed in stands from a few to several hundred acres in size. Produces mainly slack cooperage stock, lower grade factory lumber logs, and box factory logs.	(a) Pure ash: occasional small stands of pure ash may occur almost anywhere within the type but most notably on moist flats or in shallow sloughs. (b) Pure hackberry: occurs rarely on new land or front sites.
Overcup oak-bitter pecan	*Overcup oak *Bitter pecan Willow oak Nuttall oak Soft elm Cedar elm Green ash Hackberry Water locust Persimmon Red maple	Low, poorly drained flats, usually with tight clay soils; sloughs; lowest backwater basins. On low ridges with heavy soils, residual after heavy cutting in sweetgum-water oaks type.	Varies in quality from poor to medium. Widely distributed with most extensive areas in backwater basins of principal rivers.	None.
Cottonwood	*Cottonwood *Sweet pecan *Sycamore *Hackberry Willow Green ash Soft elm Silver maple Boxelder	Front land ridges and well-drained flats; rarely on abandoned fields on well-drained ridges in the first bottoms.	Pioneer type, characteristic of the fronts of all major streams. Phenomenal growth, excellent quality, and fair values for commercial veneer, standard lumber, and pulp make it one of the most valuable types.	None.

Table 1.—(Continued)

Type	Characteristic species	Occurrence by site	General features	Common variations in type
Willow	*Willow Cottonwood Green ash Persimmon Water locust Soft elm Cypress Red maple Hackberry	Front land sloughs and low flats; occasionally shallow swamps and deep sloughs throughout first bottoms.	Pioneer type on front land. Very rapid growth, excellent quality, and moderate value for factory lumber logs and pulpwood make it valuable. Usual poor quality and form make it of little value away from fronts. With cottonwood, is characteristic of fronts of most major streams but commercially important only in lower Mississippi valley.	None.
Riverfront hardwoods	*Sycamore *Sweet pecan *Green ash *Soft elm *Hackberry Silver maple Cottonwood Willow Water oak Nuttall oak Sweetgum Boxelder River birch	All front lands except deep sloughs and swamps.	Transition between cottonwood or willow and the sweetgum-water oaks type. Widely distributed but restricted in extent. Very rapid growth, moderately valuable products for factory lumber, veneer logs, and slack cooperage stock.	None.
Cypress-tupelo gum (Cypress-swamp blackgum)	*Cypress *Tupelo gum *Swamp blackgum Willow Black cottonwood Red maple Soft elm Water locust Persimmon Overcup oak Bitter pecan Sweetgum Nuttall oak Diamondleaf oak Sweet bay	Cypress-tupelo gum in very low, poorly drained flats, deep sloughs, and swamps in first bottoms and terraces. Cypress-swamp blackgum in swamp of the Coastal Plains and river estuaries.	Widely distributed in small areas. Extensive areas on lower reaches and estuaries of major streams. Potentially highest value products but growth is slow and reproduction uncertain and difficult to secure.	(a) Pure cypress: occurs scattered throughout the type. (b) Pure tupelo gum (or swamp blackgum): largely follows clear-cutting of cypress.

Application of Results

The waste factors developed in this study may be used to predict, with reasonable accuracy, the production of total heavy wood waste at most mills cutting southern pine timber. The steps in calculating wood waste are:

1. Place mill in its appropriate class.

2. Determine the percentage of annual log intake that comes from each of the diameter groups used in the present study. The records for every tenth sawing day for 6 months, or for every twentieth sawing day for a year, should be adequate for this purpose. The proportions of log intake should be expressed in percentage of green lumber tally from logs of the different diameters.

   Suggested steps in doing this are:

   a. Determine for the above period the log scale for logs of the various diameter groups.

   b. Use the average overrun percentage figures (based on green chain lumber tally) per diameter group as shown in table 4 (column 6).

3. Multiply the percent of the lumber tally in each diameter group by the factor for total waste for that group as given in table 4 (column 9).

4. The sum of these figures is the weighted amount of waste per thousand board feet of lumber produced during the sample period.

5. Multiply the weighted average amount of waste per thousand board feet by the total annual output of the mill.

Table 4.--Total and chippable pine waste from study logs

Diameter class (inches)	Mills	Logs	Net scale, Doyle	Green lumber tally	Overrun, based on green chain lumber tally	Total waste 1/,2/	Total waste per M b.f. 2/		Chippable 2/,3/		
										Waste per M b.f.	
							Doyle scale	Green lumber tally	Total chippable	Doyle scale	Green lumber tally
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
	- - Number	- -	- - Bd. ft.	- -	Percent	- - - - - - - - - -			Cords	- - - - - - - - - -	
					Class 1 Mills						
6	2	53	782	763	-2	0.60	0.76	0.78	0.58	0.74	0.76
8	4	197	3,713	6,943	87	4.45	1.20	.64	4.27	1.15	.62
11	4	205	9,288	14,611	57	7.29	.78	.50	6.93	.75	.47
14	4	201	18,125	24,596	36	9.41	.52	.38	8.75	.48	.36
17	4	93	14,212	16,669	17	5.73	.40	.34	5.22	.37	.31
20	4	41	9,211	10,142	10	3.68	.40	.36	3.35	.36	.33
23	2	7	2,187	2,179	0	.82	.38	.38	.75	.34	.34
Total or average	...	797	57,518	75,903	32	31.98	.56	.42	29.84	.52	.39
					Class 2 Mills						
6	3	48	678	755	11	.63	.93	.84	.61	.90	.81
8	4	251	4,652	9,297	100	5.27	1.13	.57	5.06	1.09	.54
11	4	226	9,725	14,919	53	6.70	.69	.45	6.36	.65	.43
14	4	167	14,796	18,312	24	6.94	.47	.38	6.45	.44	.35
17	3	35	4,896	5,664	16	1.72	.35	.30	1.56	.32	.28
20	2	19	3,812	3,862	1	1.00	.26	.26	.91	.24	.24
23	2	4	1,147	1,147	0	.24	.21	.21	.22	.19	.19
26	1	1	331	301	-9	.04	.14	.15	.04	.12	.14
Total or average	...	751	40,037	54,257	36	22.53	.56	.42	21.21	.53	.39
					Class 3 Mills						
6	4	76	1,159	1,480	28	1.37	1.18	.92	1.32	1.14	.90
8	4	287	5,195	8,957	72	7.21	1.39	.80	6.92	1.33	.77
11	4	230	9,686	13,520	40	6.52	.67	.48	6.19	.64	.46
14	4	156	13,667	16,079	18	5.66	.41	.35	5.27	.38	.33
17	4	62	9,056	9,701	7	3.09	.34	.32	2.81	.31	.29
20	3	47	10,006	10,156	1	3.04	.30	.30	2.77	.28	.27
23	2	5	1,498	1,370	-9	.40	.26	.29	.36	.24	.26
Total or average	...	863	50,267	61,263	22	27.28	.54	.44	25.64	.51	.42
					Class 4 Mills						
6	2	37	510	693	36	.49	.96	.70	.48	.94	.69
8	4	252	4,361	7,750	78	6.64	1.52	.86	6.39	1.46	.82
11	4	212	8,849	12,620	43	7.60	.86	.60	7.23	.82	.57
14	3	105	8,574	10,542	23	4.56	.53	.43	4.24	.50	.40
17	3	23	3,113	3,497	12	.94	.30	.27	.86	.28	.24
20	2	22	4,122	3,977	-4	1.16	.28	.29	1.06	.26	.27
23	1	6	1,542	1,354	-12	.37	.24	.27	.34	.22	.25
Total or average	...	657	31,071	40,433	30	21.76	.70	.54	20.59	.66	.51

1/ Moisture content of all material in this study was 50.51 percent of green weight and varied between extremes of from 34.73 to 61.34 percent. Calculated by the lumberman's method, the moisture content of all material was 102.05 and varied between extremes of 53.20 and 158.66.

2/ Minor discrepancies between means and totals are due to the fact that sufficient significant digits are not carried in the means.

3/ The proportion of total waste that was chippable was 97 percent for 6-inch logs, 96 percent for 8-inch logs, 95 percent for 11-inch logs, 93 percent for 14-inch logs, and 91 percent for 17+-inch logs. For all study logs combined, the proportion was 94 percent.

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MANAGEMENT OF BOTTOMLAND HARDWOODS

By
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FOREWORD

This bulletin describes principles and procedures involved in the management of a group of our most important forest types--bottomland hardwoods. It fills, in part, the major remaining gap in American forest management literature.

The presentation is based on years of experience in these forest types by the author, fortified by some research. Generally, however, there have not been many applicable technical studies. Fairly recently, research has been undertaken on a modest scale, but final results are still to be obtained.

It was decided to issue this report in spite of the limitations of the research background. In so doing, there is no particular fear that the presentation is hasty or faulty in any major respect. Of necessity, however, it is incomplete, and gaps remain which can be filled only as technical data and experience accumulate.

Application and understanding of the discussion will be greatly facilitated by some general forestry knowledge, because explanation and description of standard forestry terminology and methodology have not been included. Even with a general forestry background, considerable on-the-ground familiarity with the peculiar conditions of the bottomlands will be necessary to apply the recommendations.

Southern bottomland hardwood types have their greatest concentration in the Mississippi River Delta. In the aggregate, however, there is more bottomland forest acreage outside the Delta than in it, because these types occur on every major stream and many minor ones from Virginia to Texas. Essentially, the types with which this publication is concerned are those on alluvial floodplains with their intermittent fringes of colluvial soils. The only exception is the inclusion of the cypress-swamp blackgum type in the non-alluvial swamps of the Coastal Plains. The widespread southern hardwood stands in the "branch head" coves and along creeks or runs which have no alluvial floodplain are excluded. The hardwoods of the hammock and the pond sites of the southeastern Coastal Plains are also excluded.

The discussion is confined to management of bottomland forests for timber production. The place of multiple or alternative land use is beyond the scope of the paper.

Although southern bottomland hardwoods are the main subject, much of the discussion is applicable to management and utilization of hardwood forests generally. Foresters contemplating embarking on hardwood management anywhere will obtain useful concepts and recommendations from this publication.

March 1951 Chas. A. Connaughton

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MANAGEMENT OF BOTTOMLAND HARDWOODS

By
John A. Putnam[1/]
Southern Forest Experiment Station

The principles involved in the management of bottomland hardwoods are neither unique nor peculiar. Their application follows a pattern common to placing any forest land under management: namely, the first step is to learn what there is to work with, and the second is to plan a course of action. As to the actual details of management, the bottomland hardwoods do have many unique features. The discussion of these features is the main object of this publication.

Management of most forest land--and bottomland hardwoods are no exception--usually begins with some very extensive practices. To apply these practices, only elementary information is essential. Later, as management progresses, more detailed information must be obtained. Since the most likely course of development is from the extensive to the intensive, this discussion proceeds in the same way.

1/ Stationed at the Delta Branch, which is maintained in cooperation with the Mississippi Agricultural Experiment Station at Stoneville, Mississippi.

PRELIMINARY SURVEY

A simple survey of the forest and a preliminary study of logging conditions, markets, and fire and other hazards should be the starting point to management. This is mainly a get-acquainted job. It should be sufficiently detailed, however, to furnish the land manager with all the facts and information essential to a sound beginning.

Each convenient management unit or block should be inspected and classified as to timber type and class of stand. Information on timber quality, extent of damage, and other special features should be obtained by stand classes. The only estimates of volume needed at this stage are those required to classify the stands.

The conventional timber cruise, growth estimates, and management plan are not needed at this stage. These logically come later, after the first managed cut has been made. If for some special reason the cruise, growth estimates, and management plan are wanted in the beginning, there is no reason why they should not be made. The main point, however, is that these details are not essential to getting the forest under management.

With the data from the preliminary survey, the forester can lay out his forest in operating management units or compartments, select those most in need of cutting, and plan the operations to follow. The information that must be gathered in the preliminary survey is outlined in the following sections.

SITE

In bottomlands, site is important because it largely determines the combinations of species or forest types that are present. The site in turn is determined by the physiography or elevation and soil characteristics. It is not necessary to map or classify site in the preliminary survey. However, site as used herein so strongly influences type that the forester should have a clear understanding of it at the outset of his reconnaissance. The broad characteristics of bottomland sites are described, therefore, as background for type recognition.

The two major sites are first bottoms and terraces. The terraces comprise the second and older or higher bottoms. Within each of these broad groups are four secondary sites--ridges, flats, sloughs, and swamps. A fifth secondary site, peculiar to the first bottoms, is the new land or front along present or recent drainage channels.

The main differences between first bottoms and the terraces are in elevation and soil characteristics. Since the first bottoms have been formed by the present drainage system, they are of comparatively recent origin. They are subject to flooding at any over-bank stage unless protected by levees, and many areas receive backwater. The soils range from pure waxy clay to pure coarse sand, but clays and very fine sandy loams predominate. Generally the soils contain little or no silt.

Terraces were formed by earlier drainage systems. They are not subject to direct flooding except at superflood stages. The normal processes of erosion have created a definite relief in many places, and the original alluvial features--ridges, flats, sloughs, and swamps--are less evident than in first bottoms but no less important. Most terrace soils are basically silt, with varying mixtures of sand and clay. The colluvial fans and aprons, common at the foot of the rise where the bottoms and uplands merge, can be considered as parts of the terraces.

In both first bottoms and terraces, the ridges are usually the highest land, commonly varying from 2 to 15 feet in elevation above the adjoining flats. They are the banks or "fronts" of former stream courses. The flats, which are just what the name implies, constitute the general terrain between ridges. The sloughs are shallow depressions in which water collects but normally disappears during the first half of the growing season. They are either old, filled-in, or undeveloped drainage courses. Swamps are distinct depressions in which water stands throughout most or all of the growing season except in periods of drought. The new lands or fronts--including bars, islands, and towheads--have largely been deposited within the last 150 or 200 years. They are usually very fine sand and clay and are areas of unconsolidated, immature soils. There are flats, ridges, and sloughs within these fronts.

Since forest type varies with these distinct physical features, it is imperative that the forest manager know and recognize them. Throughout the detailed discussion of forest type to follow, these site distinctions will be made.

THE IMPORTANT TYPES

There are eight important forest types in the bottomlands and several significant variations of these major ones. The types are made up of various combinations of about 55 commercial species. Table 1 lists the most important bottomland forest types and describes some of their general characteristics. To prepare a sketch map showing these important types requires that the forester give the property a reasonably complete though extensive inspection. Since these types generally follow the sites or the lay of the land, judicious cut-and-try checking against air photos can save much work in determining type boundaries.

Table 1.--Southern bottomland forest types and their major characteristics

The types recognized here do not correspond to the standard types of the Society of American Foresters, because the standard types are more refined than is necessary or desirable for management purposes. (See Appendix for manner in which the Society of American Foresters types are combined in this report.) The most important or key species in each type are marked with an asterisk.

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Cottonwood	*Cottonwood *Sweet pecan *Sycamore *Hackberry Willow Green ash Soft elm Silver maple Boxelder	Front land ridges and well-drained flats; rarely on abandoned fields on well-drained ridges in the first bottoms.	Pioneer type, characteristic of the fronts of all major streams. Phenomenal growth, excellent quality, and fair values for commercial veneer, standard lumber, and pulp make it one of the most valuable types.	None.

Table 1.--(Continued)

Type	Characteristic species	Occurrence by site	General features	Common variations in type
Willow	*Willow Cottonwood Green ash Persimmon Water locust Soft elm Cypress Red maple Hackberry	Front land sloughs and low flats; occasionally shallow swamps and deep sloughs throughout first bottoms.	Pioneer type on front land. Very rapid growth, excellent quality, and moderate value for factory lumber logs and pulpwood make it valuable. Usual poor quality and form make it of little value away from fronts. With cottonwood, is characteristic of fronts of most major streams but commercially important only in lower Mississippi valley.	None.
Riverfront hardwoods	*Sycamore *Sweet pecan *Green ash *Soft elm *Hackberry Silver maple Cottonwood Willow Water oak Nuttall oak Sweetgum Boxelder River birch	All front lands except deep sloughs and swamps.	Transition between cottonwood or willow and the sweetgum-water oaks type. Widely distributed but restricted in extent. Very rapid growth, moderately valuable products for factory lumber, veneer logs, and slack cooperage stock.	None.
Cypress-tupelo gum (Cypress-swamp blackgum)	*Cypress *Tupelo gum *Swamp blackgum Willow Black cottonwood Red maple Soft elm Water locust Persimmon Overcup oak Bitter pecan Sweetgum Nuttall oak Diamondleaf oak Sweet bay	Cypress-tupelo gum in very low, poorly drained flats, deep sloughs, and swamps in first bottoms and terraces. Cypress-swamp blackgum in swamp of the Coastal Plains and river estuaries.	Widely distributed in small areas. Extensive areas on lower reaches and estuaries of major streams. Potentially highest value products but growth is slow and reproduction uncertain and difficult to secure.	(a) Pure cypress: occurs scattered throughout the type. (b) Pure tupelo gum (or swamp blackgum): largely follows clear-cutting of cypress.

Recognition of the sweetgum-water oaks, white oaks-red oaks-other hardwoods, and the riverfront hardwoods types proves complicated. There is so much variation in these types that the forest looks quite different from location to location within the same type. Frequently in type classification it will be necessary to defer recording the type boundary on a map or in notes until enough area has been covered so that the aggregate tree associations can be viewed in retrospect. By this procedure, the observations needed for the classification will accumulate in the forester's mind and he can make his judgment accordingly. Judgment of type will most frequently be based on occurrence of key species and the characteristic of the site rather than on any clearly definable feature such as volume or number of a certain kind or kinds of trees, although the final tally for any extensive area of a given type will always be characteristic as to species composition. For the other bottomland types, the characteristics and lines of demarcation are quite distinct, and little trouble will be experienced in mapping type boundaries as they are encountered. Delineation of boundaries for the hackberry-elm-ash type should be excepted. The exact boundary of this type will often be rather indeterminate.

It will be unnecessary to map or recognize types of less than 20 acres except in a few special situations which might influence logging or management.

STAND CLASSES

In order to start management, it is necessary to know which areas are operable and which are not. Ordinarily, this means segregating the saw-timber stands from the others and classifying the stands as to volume and structure. When each compartment is inspected, the stands of timber should be classified. The following classes, which an experienced forester can usually recognize without making an intensive inventory of the number and volume of trees present, are useful for economic and silvicultural planning. Where the classification is not readily apparent, plot tally of stand and volume should be made as a guide to judgment.

Stand Classes for Bottomland Hardwoods

I. Heavy saw-timber stands: 8,000 bd. ft. and more per acre in trees larger than 11 inches in d.b.h.
   a. 50 percent or more of the volume in trees 23 inches in d.b.h. or larger
   b. Less than 50 percent of volume in trees 23 inches in d.b.h. or larger

II. Medium saw-timber stands: 3,500 to 8,000 bd.ft. per acre
   a. 50 percent or more of the volume in trees 23 inches in d.b.h. or larger
      1. With adequate supporting stand of saplings and poles
      2. Without adequate supporting stand of saplings and poles
   b. Less than 50 percent of volume in trees 23 inches d.b.h. or larger. Supporting stand will be present.

III. Light saw-timber stands: 1,500 to 3,500 bd. ft. per acre
   a. 50 percent or more of the volume in trees 23 inches d.b.h. and larger
      1. With adequate supporting stand of saplings and poles
      2. Without adequate supporting stand of saplings and poles
   b. Less than 50 percent of volume in trees 23 inches d.b.h. or larger. Supporting stand will be present.

IV. Heavy pole stands: At least 175 growing stock trees per acre, 5 to 11 inches d.b.h. Natural pruning has started and stand will need thinning before it reaches small saw-timber size.

V. Light pole stands: From 45 to 175 growing stock trees per acre, 5 to 11 inches d.b.h. Stocking inadequate. Not pruning properly.
   a. With a supporting stand of saplings and seedlings which will assure satisfactory stocking
   b. Without a supporting stand of saplings and seedlings; needs reproduction.

VI. Sapling and seedling stands: At least 250 established saplings or seedlings per acre of desirable species and good form.

VII. Non-stocked stands: Less than 250 established saplings or seedlings per acre of desirable species and good form.
   a. Capable of reproducing naturally
   b. Requires planting
   c. Incapable of growing trees

Obviously timber stands do not always fall clearly and decisively into these classes. Lines of demarcation at best will be approximations based on the judgment of the forester after he has passed through the stand and observed the average predominant characteristics which define stand class. Within classes there will customarily be great variation, acre by acre. The general objective, though, should be to delineate stands of broad similarity of condition throughout, particularly as to operability and silvicultural characteristics, and then classify on the basis of average or over-all character. There is no need to labor to place minor stands and secondary subdivisions into the various classes unless distinctions are apparent and areas are of manageable shape and distribution. As a basis for judgment in stand classification and as a guide in estimating the portion of the stand which should be cut, the forester should establish occasional sample plots, recording numbers of trees and their volume and silvicultural status or condition. The main difficulty in stand classification will be in cataloging medium and light saw-timber stands.

Aerial photographs will be helpful in identifying the sapling and seedling, pole, and non-stocking stands. Field work can then be concentrated in the less easily defined classes.

Stands of heavy and medium saw timber should be mapped or recognized to a minimum size of 10 acres. For all other classes, nothing less than 20 acres need be recognized. These minimums may have to be modified locally as the situation demands.

TIMBER UTILITY, QUALITY, AND CONDITION

Generalized estimates of timber utility, quality, and silvicultural condition by stand classes are essential to determine which stands can be operated for available markets. At this stage, these estimates need only to be reasonable approximations permitting judgment with fair accuracy as to whether or not a stand is operable or when it will become operable, and roughly how much timber is available to harvest in the first cut. The saw-timber trees should be classified as overburden or desirable growing stock (these terms are defined on page 16). This classification will separate the stand into the component that should be removed and the component that should be left for growth. The overburden estimates should be broken down by the proportions in factory lumber logs and in other classes of sawlogs, and approximate numbers of cull trees. If there is special interest in a given product, such as face veneer, it can be listed separately. The average grade or general quality of the factory lumber logs and their range in quality should be estimated and recorded. Criteria to consider in recognizing class and grade of material are discussed on pages 26 ff. Observations

and records should be made also on the numbers and silvicultural condition of trees below saw-timber size. This, together with the estimates as to numbers of saw-timber-size cull trees per acre, will provide a check on the stand classification and the need of stand improvement cutting.

LOGGING CONDITIONS, MARKETS, PROTECTION

While information is being collected regarding the forest, other pertinent information helpful in placing a property under management should be gathered.

Logging Conditions

For the stands regarded as operable, a clear picture of logging conditions should be obtained during the preliminary survey. At what season can the stand be worked? This will be determined both by the drainage and soil conditions in the stand itself and by the prevailing condition influencing access to the area. How frequently do floods occur; when and how long do they last? What kind of logging equipment will be needed? Is it available now? If not, will the need for it justify its acquisition? What major transportation systems are available--highways, railroads, rivers? Can they fulfill the need? What, if any, stands will be logged by the landowner, and where should logging be contracted? If contracting appears desirable, will the opportunities interest experienced operators? What is the kind and quality of the labor supply? The fact that most information of this nature will be accumulated incidentally to other work does not belie its importance.

Markets

Somewhat related to logging conditions is the need for information on available markets. This information also may be obtained incidentally to other work, but without it planned management is impossible. What markets or uses are in prospect? How do they fit in with the nature of the timber supply? Should new or additional markets and uses be developed? If so, how and when can this be done? A later section on utilization in relation to management points out special considerations which must be taken into account in appraising bottomland hardwood marketing opportunities.

Protection

Another feature with which the preliminary survey should be concerned is the elements that must be considered in a fire protection system. This is particularly important because even rudimentary management will require a protection system. What is the fire history of the various major parts of the property? How often can fire be expected? Where are the areas of highest and lowest hazard? How will natural barriers and other physiographic features determine the protection system? What is the attitude of neighbors toward fire? Is manpower available for both presuppression and suppression work? What are the policies, plans, and operating procedures of the State fire protection organization? What special installations and equipment are needed in the fire protection system? These are typical of some of the questions that must be answered as a prerequisite to getting the area under effective fire protection.

Other protection deserves attention also. Is there any evidence of trespass and theft? Do certain areas appear to be more subject to trespass than others? Is there grazing damage to reproduction? If so, what can be done about it? Are there instances of insect attacks? Are past fire damage and rot particularly prevalent in any areas? Matters such as these will not only dictate management practices but will guide the priorities in their application.

GENERAL

Although classification of stand condition will allow operable areas to be delimited, priorities will depend on notes as to need for special or immediate attention. Are there areas of overmature timber that seem to be rapidly deteriorating? Are any areas threatened by bank-cutting by streams or rivers? Such information will come naturally and easily if the observer is on the alert.

By way of summary: When the preliminary survey is finished the forester has, first of all, an invaluable mental picture of the property. He has a general acquaintance. In addition and as background for future work, he has a map of type and stand class. Supplementing this, he has general information on the utility and quality of the stands and a rough estimate of the volume in trees to cut and leave and in culls. This information defines the operability of stands and indicates feasible silvicultural treatment. Notes and knowledge on non-operable stands and conditions are available as a guide to needed silvicultural treatment. Information has been accumulated on logging conditions and possibilities, markets, the fire situation, and other general features. He is now ready to take the next step in placing the property under management.

ESSENTIALS OF EARLY MANAGEMENT

After the preliminary survey is finished, it is time for action--actual management begins. Usually it starts with two phases of the job--installation of a protection system, and division of the property into management compartments followed by managed cutting. In these earliest phases, the intensity of management generally will be far from ideal. The protection system, however, if properly organized at the outset, will be as good as it ever need be.

PROTECTION

The first step in management is to place the property under protection. Cutting may be in progress as the protection plans shape up, but at no time should action lag in getting full protection as soon as possible. The following discussion outlines the main points in devising and installing a protection system.

Fire

Fire in bottomland forests is a very real problem, and all too often insufficient attention is given it. Fire in the bottomlands does not rage through the tree crowns, and bad fire seasons do not occur every year. Nevertheless, every 5 to 8 years a serious fire season occurs, when ground and surface fires cause very great damage.

Fire in the bottomlands usually moves rapidly along the surface, consuming the abundant shrub and weed growth and killing all tree reproduction under about 10 years of age. It also scorches the highly sensitive bark of the larger trees, causing wounds that later develop into catfaces and points of entry for rot, stain, and insects. Under extreme conditions, large saw-timber trees may be killed. A fire once every 10 years over a given area eliminates any possibility of the practice of forestry. For this reason, it is reemphasized without qualification that an effective fire protection system is a prerequisite to management.

Development and installation of this system are not strikingly different from forest fire protection elsewhere, but a few features deserve special mention.

Fire season.--With the rare exception of a dry early spring, fall is the fire season. The dangerous years are those in which the usual summer drought extends into autumn and early winter. The later the drought continues, the more fallen leaves and frost-killed vegetation are added to the fuel.

Public attitudes.--There is no compelling urge on the part of the local people to burn the woods in the bottomlands. The fires that do start are accidental. Most of them are caused by careless trespassers and by the escape of fires set for clearing fields, ditch banks, and rights-of-way. This situation is both favorable and unfavorable. It is favorable because fire does not occur often; it is unfavorable because people are unfamiliar with the destructiveness of fire and make little effort to prevent or suppress it. Awakening or increasing fire-consciousness, therefore, is important as part of the fire protection scheme.

Firebreaks, roads, and trails.--Firebreaks plowed annually late in the growing season are highly desirable. They should be at least 8 feet wide. Since their spacing depends entirely on such features as roads, sloughs, swamps, and drainage systems, it must be determined independently for each tract of timber. A very useful tool for preparing firebreaks is the Mathis four-disc plow, but any implement heavy enough to insure a clean swath is satisfactory. Continued maintenance of the firebreaks is essential during seasons of high hazard because leaves accumulate on the plowed strip.

As access may be difficult in the bottomlands, it is likely that the existing network of roads and trails on unmanaged forest land will have to be supplemented. Fire trails are not used except in fire seasons, so they need to be built only to dry weather standards.

Detection.--Air patrol during periods of high hazard is the solution to the detection problem on large properties. Methods for establishing effective air detection can be adapted to almost any large property. Fire towers are unusable because the tall timber on flat terrain obscures the view. Some ground patrol may be needed to supplement air patrol, particularly in detecting small fires in years when the fire season starts before all leaves have fallen. It should also be organized to hold trespass low during the fire season, thereby reducing the danger of fire occurrence. For small areas, detection of necessity will depend on ground patrol. Of course, where the State assumes detection responsibilities, this need will automatically be met for all properties.

Suppression.--Suppression of fires in the bottomlands generally follows standard technics except that building a fire line is unusually difficult. The vegetation is heavy and the soil is packed and hard and filled with tenacious roots. In the worst seasons, the difficulty of fire line construction puts the heaviest equipment in the South to a severe test.

Other Protection

Concentrated grazing by cattle causes severe damage to bottomland hardwood reproduction. Except for occasional very light grazing, cattle should be excluded from all areas where reproduction is needed. Hog grazing presents no serious problem.

Boundaries should be plainly marked and posted to prevent trespass and theft. Occasional inspection should be made to see whether any trespass has occurred. Friendly relations with neighbors help in reducing theft and in keeping an eye on developments.

DIVISION INTO MANAGEMENT COMPARTMENTS

Before cutting is started, a property should be divided into compartments to facilitate management and administration. Customarily, compartment boundaries will coincide with natural features such as streams, swamps, roads, and fields. Public land survey lines can also be used as compartment boundaries. It is advantageous to have compartments coincide with types as far as practicable, but stand conditions which will change under management need not be considered.

The size of compartments will vary with the size of the total property. Types, volumes, rate of cutting, frequency of cutting, and physiographic features are the kind of factors which must be considered in designing and establishing management units. Properties smaller than a few hundred acres may not require any subdivision at all.

Since compartments are the units of management, they should be very carefully selected for permanence and with the definite purpose of establishing an adequate but simple system of permanent records. All compartment boundaries should be plainly marked on the ground and on a map.

THE FIRST MANAGED CUT

The first managed cut will be somewhat of a hit-and-miss affair. It cannot be anything else, because the forester has to work with stands that have been subjected to all manner of unmanaged treatment through the years. Nonetheless, and in spite of many exceptions, there is a systematic approach which can be followed and which will yield results.

The basis for this systematic approach is the preliminary survey, which roughly classifies type and stand conditions and thus gives the forester the essential information that he needs to get

managed cutting started. Basically, he will use a common management prescription for all situations, but the details will vary with type and stand condition; and other features also will have some influence.

The discussion which immediately follows outlines first the general management prescription for the first cut and then specific prescriptions for each type and stand condition, or, where possible, for groups of types and conditions. In making the first managed cut, these recommendations should be the guide. As management intensifies, cutting methods and stand treatment can be refined as needed.

General Prescription for First Managed Cut

With only minor exceptions, the forester will find that through the years fire, unmanaged cutting, and other destructive influences have created a forest with a high proportion of low-grade and cull trees and undesirable species. In general, therefore, the first management prescription is to remove such components, plus the mature and damaged trees, in order to promote rehabilitation of desirable growing stock. During this process, the maximum possible returns in financial and silvicultural benefits will be essential. The test of the forester's skill, therefore, will be how fast he brings about full production of the land, at the same time compromising with the economic position and policy of the landowner.

In practically all bottomland forests, the effect of the general prescription will be an improvement cut supplemented with harvest of the overmature remnants of the earlier stands. Occasionally an element of thinning may be involved. The desirable growing stock should be left out of consideration until the undesirable elements of the stand are disposed of. The faster a property can be cut over in this way, the sooner it will be rehabilitated.

The actual rate at which the cut can be made will be determined by the desirability or need of supporting a specific plant or market from the area, or by the capacity of facilities or markets.

The necessary compromise of silviculture and economics--regulation of the cut--is not too difficult to make in extensive management. From the preliminary survey, an approximation of the operable areas and a very rough estimate of the volume of the components of the stand will have been secured. If sustained yield is feasible, the cut can be prorated over the years expected to elapse before the property can be cut over a second time. Otherwise, the material can be removed at the best speed circumstances permit, with cutting beginning in the decadent stands with the heaviest volumes. A plan to cover the property systematically should be made.

In general, the period allotted to removal of the undesirable components should not be more than 10 years. Although a gap in the

cutting cycle will often result, it will usually be false economics and poor silviculture to plan for any materially longer period.

If the volume of undesirable components is too great to be disposed of within a reasonable period, it is wise to postpone cutting some of the better unwanted trees until the second cutting cycle. In short, the worst should be salvaged first; this advice applies to stands as well as individual trees.

Where there is not enough material to meet the necessities of operation, plant capacity must be modified--or requirements met by purchase or trade. If these measures are not feasible, it may be justifiable to cut some of the desirable growing stock, but such cutting should be restricted as much as possible and should be concentrated on trees approaching the margin of maturity and quality. Such marginal growing stock may at times also be used to sweeten the cut in stands otherwise inoperable; but the forester should first assure himself that the silvicultural advantages of cutting in the stand more than offset the loss arising from the premature liquidation of desirable growing stock.

It must be emphasized that cutting of the desirable growing stock is always the very last expedient to be considered. If such cutting is done, it must be held to an absolute minimum. It will usually be better to suspend cutting entirely rather than to cut materially into desirable growing stock before rehabilitation is well along. For the purposes of sustained yield, such cutting is merely an insidious form of silvicultural suicide.

All this means that in the early stages of management the only material available for cutting is the accumulation of undesirable growing stock. Calculations of growth are therefore not pertinent to the early cuts. By their nature, the undesirable trees will provide little or no net growth, while the increment on the desirable trees must be retained for stand rehabilitation.

Unmanaged stands generally have a large component of trees useless for anything but firewood--that is, trees which are unsound, low-grade, malformed, and of weed species. The growing capacity of the average stand at present is reduced about 20 percent by these trees--one acre in every five is unproductive because unmerchantable trees preempt the space. Usually the only way to handle the problem is to girdle or poison such trees as rapidly as opportunity permits. Occasionally a good den tree should be left for wildlife propagation even though it is unmerchantable.

Marking for the First Cut

Marking a stand for the first improvement-harvest cut is a matter of selecting trees which should be cut from the standpoint of silviculture and which will pay their way. These trees should be selected for cutting on an individual basis, and no cutting should ever be done unless the stand is first marked. Each tree marked should be tallied by diameter class and merchantable height and classified according to the products for which it will be utilized. If the timber is to be sold on a log-scale basis or delivered to the owner's plant, there is no particular need for tallying trees as they are marked, except for the record.

In thinking of the stand in terms of its cutting needs, the forester will find it convenient to divide the trees into two classes--desirable growing stock and overburden.

Desirable growing stock includes all trees which, in the judgment of the forester, should be left for one cutting cycle or more. It includes trees that seem likely to grow to merchantable size and quality, as well as those now in this class.

Everything else is overburden--that is, trees unlikely to make a net contribution to the value of the stand over the estimated period before another cutting. Overburden trees range from rotten culls to highly merchantable trees that are ripe for harvest. Overburden trees may be overmature or decadent, or they may be taking up too much growing space. They may be suppressing or being suppressed by better trees. They may show severe damage from fire, wind, logging, rot, or insects, or may be of poor form, quality, or species.

In dealing with overburden, it is helpful to distinguish the cull component into two classes, sound and rotten. A sound cull is a tree so malformed or limby that if it is of saw-timber size it does not contain one 12-foot log of tie-and-timber class or better; or, if it is below saw-timber size, it cannot be expected to produce one such log through further growth. Rotten culls are any trees, originally growing stock, in which rot has destroyed at least 50 percent of the stem volume that would otherwise be usable. Rotten culls are wholly useless, but sound culls may have some slight utility.

The criteria that distinguish overburden are broadly those which determine selection for cutting under the conventional selection systems of silviculture, with special emphasis on present and potential merchantability. Species, utility, and quality are important as they bear on the economic desirability of the individual trees; and species, vigor, extent of injury, and competitive position in the stand must be considered as they affect silvicultural desirability.

Species.--Hardwoods are much more variable than softwoods in silvics and utility. In marking, the forester must always balance these two aspects against each other, remembering that growth capacity, form, tolerance, reproductive ability, quality, absence of defects, or adaptation to site may justify leaving a tree of a species of lower utility in preference to one of high species utility. A cow oak, for example, should not always be kept, nor should all bitter pecans be cut.

Utility and quality.--Whether or not a tree, or a log within a tree, is adapted to a given use depends on its soundness, species, and the nature of its defects. Thus large high-grade white oak logs are useful for tight cooperage, but very rough, sound white oaks are suitable only for cross ties or fence posts. No sweetgum, however large and clear, can ever be used for tight cooperage, though it is very desirable for face veneer and slack cooperage.

For each use or utility, there are factors of quality which are expressed by grade. The principles upon which hardwood utility and quality are based are not particularly difficult to grasp, but the use classes and log grades must be understood before a good selling job can be done. Especially in the run-down stands with which the forester will be dealing, neglect or ignorance of the principles of utility and quality will invariably cause difficulty and embarrassment. The principles of utilization are discussed in a later chapter, and the appendix lists the uses and characteristics of the various species. Information on recognition and interpretation of defects is also available.2/ Study of these references, coupled with observation and experience, should enable the forester to do a reasonably good job of evaluating utility and quality.

Vigor.--The vigor of a tree is a measure of its general health and its ability to respond to release. It is an indication of capacity to grow. Trees with insufficient vigor to live until the next cutting cycle should be cut, as should those which are growing in diameter at an unacceptable rate at the time of marking and which have no prospects of responding to release. Whether growth rate is acceptable will be determined primarily from the size of the tree and its quality.

Vigor can be recognized in the general appearance of the tree. Among the best indicators are bark characteristics: the color, luster, thickness, smoothness, texture, amount of fissuring, shape of ridges, and degree of scaliness or plating. The shape of the

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2/ Lockard, C. R., Putnam, J. A., and Carpenter, R. D. Log defects in southern hardwoods. U. S. Dept. Agr. Agr. Handbook 4, 37 pp., illus. 1950. For sale by the Superintendent of Documents, Washington 25, D. C., 25 cents.

crown; the color, luster, and density of foliage; the crown-stem ratio; presence of dead or dying branches in the upper crown; and relative proportion of fine, growing shoots compared to short, gnarly, or club-like branches are further indications of vigor.[3]

Occurrence and extent of injury.--In many bottomland stands, most of the trees removed in the first managed cut will be injured trees. Injury or insect infestation not sufficiently serious to threaten to kill a tree or prevent it from increasing in value during the next cutting cycle is not in itself reason for cutting. However, the damaged tree should always be marked when there is a choice between competing trees which are otherwise similar.

Identification and evaluation of injury require on-the-ground observations. Of all the injuries, those resulting from past fires are by far the most prevalent. They are also more serious than all others combined. However, not all fire scars indicate that the value of the tree has seriously decreased or will decrease during the next cutting cycle. Mere presence of recent or incipient fire injury is not enough in itself to require marking.

Competitive position in the stand.--Competition among desirable trees is not ordinarily critical at the time of the first managed cut. Occasionally, however, the reason for marking a tree will be to improve the competitive position of a more desirable individual. For example, if a vigorous ash pole is being overtopped by an otherwise desirable soft elm of commercial size, the elm should be cut. Use of this criterion for marking requires judgment for which no specific instructions can now be given. Skill will come with experience. Rarely will thinning in the ordinary sense be a reason for marking much timber in the first managed cut in the bottomlands.

Applying General Prescription to Stand Classes

The foregoing general criteria for guiding the marking in the first managed cut apply to all stand classes. The details of their application and the effects vary by stand classes and the management needs of each class. The variations are reflected in the silvicultural results of the cutting and in the amount and kind of products. The variations which will be experienced in the various stand classes are summarized in table 2 (pages 20-21).

3/ For a method of determining whether growth rate is acceptable and for further information on the recognition of vigor classes, see: Guttenberg, Sam, and Putnam, John A. Financial maturity of bottomland red oaks and sweetgum. South. For. Exp. Sta. Occas. Paper 117, illus. 1951.

It should be recognized that the utilization opportunities will determine the manner in which the cuts visualized in table 2 are applied to the various stand classes. Generally, for the better stocked, more highly valued stands, there will be no difficulty; but the poorer in quality the stand becomes, the more difficult it will be from the standpoint of economics to follow through with the recommended silviculture. Table 2 assumes full utilization for all classes of material.

All kinds of usable material may be present in any class of stands, but for brevity's sake only those kinds which determine the feasibility of cut are specifically mentioned in the table.

Type Influences Treatment

For the sweetgum-water oaks, white oaks-red oaks-other hardwoods, and riverfront hardwoods types, the three most widespread and most variable types in tree size and species composition, table 2 applies without qualification. The main variations from the table occur in the group of types which is restricted in tree size distribution and species composition and also in the group which is restricted in species composition only.

Treatment of types tending toward single species and single age or size class

This group, which comprises about 25 percent of the bottomland forest area, includes the following types or variations. All except the cypress-tupelo are temporary types.

1. Cottonwood

2. Willow

3. Cypress-tupelo

4. Sweetgum-water oaks, predominantly sweetgum variation

5. White oaks-red oaks-other hardwoods, white oaks variation

6. Hackberry-elm-ash
   a. Pure ash variation
   b. Pure hackberry variation

7. Riverfront hardwoods
   a. Pure sycamore variation
   b. Pure silver maple variation

Table 2.--Stand classes: their characteristics and nature of the first commercial improvement cut

Stand class	Nature of stand and products	Cutting objectives	Cutting priority	Silvicultural results of the cut
I. Heavy saw timber (8,000 bd. ft. and more per acre)				
a. 50 percent or more of the volume in trees 23 inches d.b.h. and larger	Largest and best trees usually overmature. Products mostly factory and veneer logs.	Harvest of mature timber, salvage of overmature and damaged trees.	Highest; large values at risk, highly operable.	Sparse residual stand, often good in thrifty groups.
b. Less than 50 percent of the volume in trees 23 inches d.b.h. or larger	Skilled cutting especially desirable, as this class has best possibility of early formal management. Factory logs predominate, but great variety in size and utility of products within and between stands.	Normally stand improvement and release; occasionally salvage; secondarily harvest.	Medium; high if damaged.	Good residual stand except where much timber is overmature and damaged.
II. Medium saw timber (3,500-8,000 bd. ft. per acre)				
a. 50 percent or more of the volume in trees 23 inches d.b.h. and larger				
1. Adequate supporting stand	Large trees--mostly residual old growth; overstory often seriously obstructing promising second growth. Factory logs of many sizes but mostly of medium to poor quality.	Harvest, salvage, stand improvement, release.	High; strong salvage considerations and early possibility of developing sustained yield. Highly operable.	Fair to good residual stand, scattered or in groups.
2. Same as above, but inadequate supporting stand	Saw-timber overstory usually in very poor condition from same causes that damaged or eliminated understory. Products largely factory logs of good size but medium to poor quality; also considerable tie-and-timber logs. Species composition often poor.	Harvest, salvage, stand improvement.	High; next after class I-a because of urgency of salvage and desirability of promoting reproduction.	Sparse residual stand in need of regeneration.
b. Less than 50 percent of the volume in trees 23 inches d.b.h. and larger. Supporting stand will be present.1/	If undamaged, fair chance of sustained yield after first cut. Factory logs medium to poor in size and quality and often only a small majority of total. Tie-and-timber log volume large, sometimes good deal of bolt stock and pulpwood.	Stand improvement, release, occasionally salvage.	Low; small values at stake. Further development will greatly increase operability. Medium priority if damaged.	Good residual stand unless original stand had heavy early damage or sparse understory.
III. Light saw timber (1,500-3,500 bd. ft. per acre)				
a. 50 percent or more of the volume in trees 23 inches d.b.h. or larger				
1. Adequate supporting stand	Cut will usually be near minimum operable volume. Products will range widely in size and quality, but saw timber predominates, running half factory logs, half tie-and-timber logs. Very desirable to integrate saw timber with other uses.	Harvest, salvage, stand improvement, release.	Low; small value involved, and hard to market the products. Medium priority if of maximum volume and seriously damaged.	Good to sparse residual stand, depending on damage and development of supporting stand.
2. Same as above, but without supporting stand	Stands mainly residual old growth following heavy cutting and repeated burning or grazing. Products chiefly sawlogs, about half factory and half tie-and-timber.	Harvest and salvage; stand improvement incidental.	Lowest or next to lowest; values small and reproduction usually comes in with protection. Medium priority in rare instances when salvage at stake.	Sparse residual stand needing reproduction.
b. Less than 50 percent of volume in trees 23 inches d.b.h. or larger. Supporting stand will be present.	Only the best such stands are operable. Sawlogs; often runs strongly to tie-and-timber logs, but all products usually occur in substantial amounts. Integrated operation generally imperative.	Stand improvement, release, harvest, salvage.	Lowest of any saw-timber stand, as products hard to market, low values at stake, and saplings and poles usually develop satisfactorily for time being if left alone. Need for salvage or existence of markets raises priority.	Good residual stand.
IV. Heavy pole stand (more than 175 trees per acre 5 to 11 inches d.b.h.	Stands are mainly even-aged. Excellent chance of early formal management if not seriously damaged. Products almost entirely pulpwood and chemical wood, rarely piling or low-grade local-use sawlogs.	Thinning and stand improvement; occasional salvage.	High if not badly damaged; then low because of low present values.	Excellent young residual stand with great possibilities.

1/ Rarely a medium stand of saw timber with less than 50 percent of volume in trees 23 inches d.b.h. or larger may be encountered without a supporting stand of small trees. If it occurs, treat as "medium saw timber (large) without supporting stand" if the stand volume is in the upper range of its class; treat as "light saw timber without supporting stand" if stand volume is in lower range of its class.

Table 2.—(Continued)

Stand class	Nature of stand and products	Cutting objectives	Cutting priority	Silvicultural results of the cut
V. Light pole stand (less than 175 trees per acre 5-11 inches d.b.h.)				
a. With supporting stand of saplings	One of commonest conditions. Products mainly low-grade cordwood and posts, occasionally traces of low-grade, local-use sawlogs.	Mainly stand improvement and release; occasional salvage.	Medium.	Sparse residual stand but established reproduction has good future.
b. Without supporting stand of saplings	Same as above.	Stand improvement, occasional salvage.	Lowest of any condition. Generally little can be done except to get regeneration.	Very sparse residual stand. Reproduction badly needed.
VI. Saplings and seedlings (at least 250 trees per acre)	Low-grade cordwood, traces of saw timber, largely low-grade, local-use logs. Total too light for commercial operation.	Release and stand improvement.	Very low. With protection will usually develop satisfactorily for time being.	Reproduction promising.
VII. Non-stocked (all potentially productive conditions)	No produce, except perhaps a little low-grade local-use material.	Elimination of undesirable seed source and clearing as site preparation.	Generally cutting is not essential.	Elimination of undesirable seed source.

The cottonwood, willow, and cypress-tupelo types, and the pure ash variation of the hackberry-elm-ash type should be handled on an even-aged basis. The others may be handled either as even-aged or all-aged stands, depending on management objectives. In uneven-aged management, it will not be possible to maintain pure stands, as more tolerant species will invade. Skillful management, though, can maintain predominance of the desired species. Generally, the stands in these types are pretty well stocked with trees of fair to good quality. Because of these silvical characteristics, stand treatment will tend toward thinnings as a basic approach, rather than the salvage or improvement cutting that dominates the approach in the major types, which usually have larger proportions of damaged and malformed trees.

In the rather rare instances where heavily stocked overmature cottonwood stands are encountered, the best approach is to clear-cut, with the expectation of natural regeneration by other riverfront hardwoods. In younger cottonwood stands, it is well to anticipate the ultimate replacement of the type by more tolerant species. Intermediate cuts should be planned to maintain optimum growth of the residual cottonwood and at the same time encourage establishment of the succeeding stand. By the time the final cut of cottonwood is made, an adequate understory of acceptable species should be ready to take over the site.

Special attention must be paid to the immediate management of willow stands. Willow grows very rapidly and does not assert dominance. This means that in normally well-stocked stands thinnings must start just as soon as they are economically feasible and must be continued at intervals of about 5 years. Thinnings should be from below. In unmanaged willow stands, as much as half of the volume may be lost from competition in 5 to 8 years.

For the white oaks variation, special handling is desirable if the type is to be maintained. Treatment will emphasize stand improvement or cleaning directed at eliminating undesirable species like hickory, red oak, and winged elm. Because of the gap in seed years and the fact that the oak mast is especially palatable to animals, cutting should be gaged insofar as practicable to coincide with heavy seed years, which occur, on the average, every 6 to 8 years.

If young stands of sycamore and silver maple are to be developed satisfactorily, cleanings are usually needed to remove invading box elder and inferior individuals of hackberry, soft elm, and sweet pecan.

As a general circumstance, except for cypress-tupelo, special pre-harvest measures such as weeding and site preparation will be necessary to regenerate all these types and variations, and planting

will ordinarily be needed for the cottonwood type. However, the mixed types which normally succeed these types are usually fully satisfactory for management objectives.

Treatment of types limited as to species composition but variable as to tree size or age

These types and variations are characterized by a lack of variety in species composition. They are usually all-aged by groups and they occupy about 35 percent of the bottomland area. Generally, the species distinguishing the type or variation make up at least two-thirds of the volume. In many instances, all of these except the water oaks variation have been derived from better quality types by repeated excessive cutting plus fire. The stands are usually light and occupy the poorer sites or abused favorable sites.

Cutting in these types or variations should accent harvest or salvage aimed at stand improvement. Wherever the local site permits, the objective should be to convert to more productive types; otherwise, the forester should endeavor to improve the quality of existing types. Almost without exception, drastic stand improvement measures are essential to direct the silvicultural trend properly.

This group includes:

1. Overcup oak-bitter pecan

2. Hackberry-elm-ash

3. Sweetgum-water oaks
   a. Water oaks variation
   b. Cedar elm-water oaks variation

The sites occupied by these types and variations are the most susceptible in the bottomlands to the invasion of buckvine. As well-established buckvine is the one form of ground cover with which tree seedlings cannot compete, it must not be allowed to start ahead of the trees. To avoid preemption of the sites susceptible to buckvine invasion, openings created by cutting must be seeded promptly. This can only be attained by maintaining a desirable and adequate seed source. Fire protection is absolutely essential, for fire encourages the spread of buckvine by killing other vegetation and promoting the sprouting of buckvine. Where buckvine is already densely established, stand improvement is futile. Such areas will require development of special treatments to eradicate the buckvine.

Heavy stand improvement is usually needed in these types or variations. Achievement of such improvement by stages is recommended, both because it avoids opening the stand excessively at any one time

and because it usually fits in best with the landowner's desires. In order to improve species composition, cull trees of the better quality species should often be left for seed. Priority in treatment should be given to areas where results are likely to be pronounced and immediate.

Handling Unmerchantable Components

In each and every stand class there are some overburden trees that cannot be marketed. The amount and percentage of this material is determined by the kind, utility, and quality of the stand in relation to the markets available or anticipated. The younger and poorer the class of stand and the poorer the markets, the greater the difficulty; but even in the best quality saw-timber stands the problem is present. To place the stand in the best condition for future growth and development, money or effort must be expended to kill unmarketable trees, even though they are large enough to have commercial value if a local market existed. The handling of this unmerchantable portion of the overburden then becomes a job distinct from the commercial operation.

In young stands and in low-quality stands, the job is bigger in proportion to the total management job than in the older and better stands. No greater skill is required in these stands, but the higher percentage of non-saw-timber overburden increases the difficulty.

It is fully recognized that a silvicultural investment (a current cost not currently offset by sales) rarely appeals to a landowner. The question of how large an investment is justified must be worked out on the ground independently for each situation, bearing in mind that in any case future benefits must exceed costs to justify the investment.

Removing the unmerchantable overburden

It is usually best to mark the unmerchantable trees that are to be eliminated after the commercial operation is completed. The marking will be influenced and limited by the investment per acre which the landowner is prepared to make. It may remove all the unmerchantable overburden, or it may be a light treatment which liquidates only those trees that are most harmful to the stand and which covers only the areas most in need of improvement. Some degree of selective treatment, relating prospective benefit to cost, will attain the greatest return on the investment. At the present stage of bottomland forestry, more often than not, the treatment will be partial rather than complete.

Unmerchantable overburden trees can be removed by felling, but deadening on the stump, by girdling or poisoning, is cheaper. Effective girdling requires complete severance of the cambium (often with a deep notch into the sapwood), and when trees are under 10 to 12 inches in diameter, profuse sprouting may follow. Poisons have the advantage of greatly reducing sprouting. Use of "Ammate" (ammonium sulfamate) crystals applied in notches at the base of the tree, or Ammate solution in frills at breast height is very effective in the uplands.4/ This treatment has not been adequately studied in the bottomlands and it deserves further check. Sodium arsenite is a very effective poison to bottomland hardwoods when applied as a solution in frills.5/ However, because it is highly toxic to man and animals it is hazardous to use. New information is constantly becoming available on the use of chemicals, and the forester should acquaint himself on the status of knowledge immediately before undertaking any poisoning work. On the whole, it now seems that application of one of the poisons in a frill will ultimately prove to be the most economical method and probably will be sufficiently effective.

Cautions to observe

In applying stand improvement measures, care should be taken not to open the crown canopy to the point where buckvine takes over the site or undue epicormic branching occurs. The latter phenomenon may not be very important, but the dangers should not be overlooked.6/ Additional research is needed on this problem before specific instructions can be given.

Obviously, it is important that all markets be explored before any trees are deadened. In view of the complex nature of hardwood utilization and markets, this undertaking challenges the ingenuity, imagination, and energy of any forester. A thorough familiarity with utilization in relation to management is required. This subject is discussed in the section to follow.

4/ Peevy, Fred A. How to control southern upland hardwoods with Ammate. U. S. Dept. Agr. M-5296, 7 pp., illus. 1949.

5/ Maisenhelder, Louis C. Poisoning of bottomland hardwoods. Miss. Agr. Expt. Sta. Cir. 139, 7 pp., illus. 1948.

6/ Jemison, George M., and Schumacher, F. X. Epicormic branching in old-growth Appalachian hardwoods. Jour. Forestry 46: 252-255. April 1948.

Wahlenberg, W. G. Epicormic branching of young yellow-poplar. Jour. Forestry 48:417-419. Sept. 1950.

INFLUENCE OF UTILIZATION ON MANAGEMENT

The fundamentals of utilizing and marketing hardwoods conform to very definite patterns and customs which are unique in themselves and quite different from the pattern for softwoods. This point is emphasized at the start because the factors associated with softwood utilization are those that have usually guided the forestry profession in the relation between utilization and management. The differences between hardwood and softwood utilization exist in all hardwood types, but the greatest contrasts are found in the bottomlands.

PECULIARITIES OF HARDWOOD UTILIZATION

Bottomland forests are characterized by a great variety of species and by great variation in quality and form of trees and logs within species. Since the species have markedly different inherent utility, and since the variations in quality and form further influence utility, it is apparent that a great many uses are possible for the products of a forest.

Ten or twelve species, ranging from sweetgum to almost worthless rock elm, may be found on a single acre. One sound sweetgum may produce high-quality veneer logs, while another nearby will yield at best only low-grade crating lumber. Often whole trees, because of small size, crookedness, or defect, will cut out only bolt, post, and cordwood material. Portions of sawlog trees will have similar limited utility. Within each use-class of material, there are gradations in quality which can be segregated into groups of like adaptability or grades. Understanding of the utility classes, and the grades within them, and recognition of what these requirements and specifications mean in applied forest management are essential skills for the bottomland forester.

Utility Classes

Despite their heterogeneity, the uses of bottomland hardwoods fall into five broad classes of logs and round products. These utility classes can be consistently recognized in standing timber. Ranged in order from the lowest to the highest in value, they are:

1. Fuel wood
2. Pulp and chemical wood
3. Posts, props, and piling

4. Bolts, including some 8-foot logs
   a. Common stock, suitable only for boxing, crating, blocking, and the like
   b. Quality stock, suitable for small dimension, veneer, cooperage stock, and specialties

5. Sawlogs
   a. Local-use logs
   b. Tie-and-timber logs (logs for any standard structural lumber)
   c. Factory lumber logs (covers all industrial uses requiring broadly similar round timber: e.g., slack cooperage stock, and package and commercial veneer)
   d. Face veneer and tight cooperage logs

The huge variations in utility bring about corresponding variations--much greater than are ever seen by pine forest managers--in the demand for and value of the products from a bottomland forest. Logs for face veneer may sell for several hundred dollars per thousand board feet, while local-use logs may not justify the expense of manufacture.

For the higher uses, the requirements and specifications are very exacting. Frequently they are based on appearance, as with furniture and face veneer. For other products, such as handles, great strength and other technical qualities may be the determining characteristics.

Grades

Formal grades have been developed only for factory lumber logs, and even here they have been in use for such a short time that they are not widely applied. For all classes of material, however, very important grading processes based on local experience and judgment do take place.

Fuel wood.--Although it is stretching a point to describe them, experience and custom recognize informal fuel wood classes or grades which influence the sale price and acceptability of the wood. The heavier species such as oaks and hickories make the best firewood, whereas light species such as hackberry, cottonwood, and willow are less desirable. Size, straightness, soundness, and ease of splitting are also recognized as affecting value.

Pulpwood and chemical wood.--Though actual value is known to vary greatly, there are no grades for pulp or chemical wood except "acceptable" and "unacceptable." Specifications as to species, size, form, and soundness make this division. There is great diversity in local specifications.

Posts, props, and piling.--The main volume of use here is for posts. Local post specifications vary greatly. For props and piling, commercial specifications are established and well observed.7/

Bolts, including some 8-foot logs.--Although local custom and trade recognize and follow specifications for bolts, no standard grades have been established.

Sawlogs.—There are no standard grades except for factory lumber logs, but veneer log specifications having the practical effect of grades are commonly applied independently by the various buyers.

The standard grades for factory lumber logs were developed by the U. S. Forest Products Laboratory.8/ They are based on the proportion and arrangement of clear (defect-free) space on the log surface. The grades are designed to permit sorting logs into groups based on their grade yield of lumber (by National Hardwood Lumber Association grades). The proportion of clear cuttings which can be obtained in remanufacture is the basis for grading the lumber and in turn the real basis for grading the logs.

This principle contrasts strikingly with grading softwoods. The difference lies in that hardwood lumber is commonly destined for remanufacture into articles of beauty or technical utility, while a piece of softwood lumber is regarded primarily as a final product or structural unit. This difference means that defects, including knots, for the two kinds of lumber are regarded and handled very differently. Any imperfection or blemish in hardwoods limits a clear cutting and is therefore a defect.9/ This is true regardless of the size or soundness of the defect, and distribution of defects is more important than their number, size, or character. In softwood lumber, the seriousness of the imperfection depends on its size and character--that is, whether it will weaken the piece. Number and distribution of defects are much less important.

7/ Standard specifications for round timber piles. Designation D 25-37, American Society for Testing Materials, 260 S. Broad Street, Philadelphia 2, Pennsylvania.

8/ Hardwood log grades for standard lumber: proposals and results. U. S. Forest Products Laboratory No. D1737, illus. 1949.

9/ See pages 3 to 5 in "Log defects in southern hardwoods," cited in footnote 2, page 17.

The local grades or customs and practices in regard to veneer and stave logs all depend on the same basic principle as the grades for factory lumber logs, namely, the proportion of clear cuttings that can be obtained from the log.

Standard classes and grades for local-use and tie-and-timber logs have never been developed. When they are prepared they will be based primarily on the principles followed in grading softwoods, rather than those used in grading hardwoods. Defects in logs of these two classes are recognized and regarded essentially as they are in softwoods.

CORRELATING MANAGEMENT AND UTILIZATION

The foregoing fundamentals of hardwood utilization have a decisive effect upon the intensity of management which can be practiced. For material that meets the requirements of the higher uses, no particular marketing or utilization problem exists. In operable stands containing factory lumber logs and better products, the management prescriptions outlined earlier can be followed with comparative ease.

Difficulties increase as the proportion of the lower utility classes in the stands increases and the volume of the higher classes decreases. Market limitations may first exclude the smaller sizes and less desirable species of factory logs but are not ordinarily serious for this class of logs. By and large, the limitations become more serious in tie-and-timber logs, and are extremely serious for all local-use logs and non-sawlog material. The exact utility and quality level at which the problem becomes acute varies greatly from place to place and time to time and may be expected to decline generally, but even when lower class products can be sold at some profit, it will always be easier and more remunerative to sell the higher utility classes.

The Need for Integrated Utilization

It is estimated that not over a third of the present bottomland forest area is operable for factory lumber logs, even under cutting practices which disregard the need for conserving the growing stock. If cutting is restricted to the overburden, as it should be under management, perhaps only about 25 percent of the area can readily be given a commercially profitable cutting for factory lumber logs. Or, in reverse, three-fourths of the area, of which a large proportion has some saw timber, will not support a cutting (solely for this product) that is both silviculturally sound and commercially profitable.

To a limited extent, stands without an operable factory lumber log component are being worked economically for other saw-timber products such as cross ties. Such operations, if properly directed, can be very favorable to silviculture. In the main, however, over much of the bottomland area, good silviculture depends largely upon removal of classes of material that cannot be manufactured at a profit under available markets.

As operable sawlog stands offer an immediate opportunity for applied silviculture, most commercial management can and will begin in such areas. It is in the marginal stands, however, that the forester's skill in utilization will determine to a great degree whether bottomland hardwood management is practical. The only alternative to utilization is an outlay for stand improvement work, but the greater the need for such work, the less attractive it seems as an investment, even though it may be perfectly sound on a long-term basis.

Some system of integrated marketing seems the soundest approach to hardwood silviculture. No single class of utilization will result in maximum volume utilization and maximum value return at the same time. Sale of the entire usable content of the stand for a single use would be possible only if all the material went into the lowest use class involved, but this procedure would sacrifice values in the higher classes of material. On the other hand, selling the stand for the highest class of material present in substantial proportion leaves unutilized much of the total volume in lower class wood. By putting each class of material to its highest use, integrated marketing would make it possible to manage stands profitably which otherwise would be uneconomical to operate. It would also put the maximum area under the forester's direction and care. In working out management plans and techniques, therefore, the forester should take every opportunity to develop an integrated market which, insofar as possible, will carry over to an integrated operation in the woods.

In general, the development of such a market will hinge on two things. First, it will depend on the existence, within a given territory, of industries which compete with each other for wood, but whose total raw-material requirements include all utility classes of timber insofar as possible. The second requirement for an integrated market is the development of a class of log and timber jobbers to act as middlemen catering to this diverse industry.

Current Utilization Practices

Several features of customary utilization practices relative to the use of hardwood timber should be recognized in planning for management. These are discussed briefly by classes of materials.

Fuel wood

This is one of the two or three principal uses of round timber. Although substantial amounts are sold in most towns and small cities adjacent to bottomland stands, it is handled almost entirely by unorganized, individual, part-time enterprise. Most of it is cut on farms and plantations, with little or no regard for possible higher uses of the trees or of the silvicultural consequences. Near well-settled agricultural communities, the actual and potential effects on the forest are tremendous for better or for worse. Methods of production, distribution, and use are archaic and the ultimate in inefficiency. Improvement might help make this use a most constructive silvicultural tool.

Pulp and chemical wood

A small volume of a few species is used for pulpwood, but such use is erratic and spotty as to time and location. A common practice is to clear-cut promising young stands of lumber and veneer species. With the probable expansion of the dissolving pulp industry using southern hardwoods, there is hope that proper pulpwood utilization may become of real practical benefit in expanding bottomland hardwood utilization and in turn favorably affecting management. Utilization of chemical wood is similar but much less extensive, and its future appears dim.

Posts, mine props, and piling

Most of the firm, tough species that produce reasonably well-formed stems are used on occasion for piling. However, this use is generally on such a small scale, and so local and sporadic, as to be of little significance. Whether it could be developed is questionable. Mine prop use depends more upon proximity to the mines than upon forest type or species, and very little bottomland forest is well situated in this respect.

Posts are the important item under this heading. Both durable and non-durable species are used widely--so much, in fact, that the supply of durable species for post making is about exhausted in most stands accessible to agricultural communities. Most non-durable species can be given preservative treatment by simple methods adapted to domestic and local production.

Post production and use presently is on about the same slipshod, wasteful basis as fuel wood production and closely related to it. The possibilities of organizing it to the great benefit of silviculture are very substantial.

Bolt stock

A common or merely sound grade of bolts, generally 10 inches in diameter and larger and 4 feet (or sometimes even less) up to 8 feet in length, has limited use for boxing and crating, low-class slack cooperage, and cross ties. Most bolts, though, are cut from logs of standard length. The industries which buy bolts are rather localized, tending to individual specialization, including such odd items as tie plugs and paper plugs. The largest and most generalized use is for fruit and vegetable crating, with the amount, kind, and quality of crates closely tied to the agriculture of the local area. Low-quality wood suffices for such stock, but cutters take whatever suitable timber they can find.

Quality bolt stock is used for a great variety of items from lollipop handles to high-grade veneer. Sizes, specifications, and species vary with the product. Bolts are made down to 10 or 12 inches in diameter, if of excellent quality, and down to 30 inches in length; first-class ash, hickory, and persimmon may go down to 8 inches in diameter. The material is frequently taken out of the woods in log lengths.

Veneers, small dimension, implement and athletic goods, handles, both slack and tight cooperage, and textile equipment are important items produced from quality bolts. Most of the timber used is cut into standard logs, but some high-quality material that will not yield standard logs because of small size, or sweep, or inherent short length is harvested and used as bolts. These uses are widely but thinly spread, and log procurement is coming to be integrated with the lumber operation to some extent. The markets are rather specialized and spotty.

Sawlogs

Local use.--The lowest class of sawlog, the so-called local-use log, actually has two broad classes of use. The first is the strictly local, domestic, farm use. The other is production of low-class, local material such as foundry crating and car blocking, sawed mine timber, and ungraded building material for local retail sale. Although users cut whatever and as good timber as they can get, the bulk of their needs requires only that logs produce items that are essentially sound. Considerable waste is permitted in reworking for final use. The minimum specifications for this class of logs admit material which is economically submarginal for either factory lumber or standard structural items.

Local uses are well established and traditional, but only within agricultural communities or near industrial and mining centers. The use has been largely disorganized, inefficient, and in such small volume that the impact on timber supply is very localized. Considering

the present trend in cost and utility of softwood lumber, however, it should be possible to expand and organize this type of production. If cutting is properly done, great silvicultural benefit could be realized by harvesting trees that are too poor for factory lumber logs or tie-and-timber logs.

Tie and timber.--Tie-and-timber logs are the lowest class of logs suitable for standard products handled in organized commerce. In addition to heavy structural timbers and ties, this use includes some commercially graded construction boards and smaller timbers. Production of this light material is in the pioneering stage and is still small in volume and inherently confined to the soft-textured woods. Development of future markets for this light structural stock offers a novel opportunity for any branch of the hardwood lumber industry, especially where the haul to consuming centers is short.

Production of heavy oak and gum timbers and ties is a long-established, distinct branch of the hardwood industry. Increased output of hardwood timbers and improved integration with the lumber industry is practicable and would aid in solving the problem of harmonizing utilization and management.

Factory lumber.--As has been stated, this class offers no particular utilization problem.

Face veneer, tight cooperage, and specialty.--These very high-class special-use logs represent broadly an extension and intensification of the same principles and considerations applicable to factory lumber logs. The demand generally exceeds the supply, especially since lumber and even lower use classes encroach upon the supply to a great extent. Profitable sale of such material is seldom any problem except as economic handling and concentration of scattered small lots of it are involved. Rarely are present-day stands exploited for these uses alone (except tight cooperage), for stands containing more than a few scattered trees of suitable size and quality are few and far between. Integration of face veneer and specialty log production with factory lumber log cutting is fairly good.

REGENERATION

NATURAL REPRODUCTION

In most of the bottomland forests, natural reproduction is normally adequate and dependable in amount, quality, and species. To foresters whose experience has been mainly with pine, however, or in the northern part of the country, it will probably seem that reproduction is too sparse throughout the forest, and that nearly all open areas are a hopeless snarl or jungle of weeds, vines, and brush.

Conditions for Securing Natural Reproduction

Except for a limited number of species such as hackberry, mulberry, and the elms and hickories, which are mostly of secondary importance or even undesirable, the important bottomland hardwood species are intolerant of shade. Hence advance reproduction is rare, and even depleted stands will have young stock only in openings large enough to allow direct sunlight to reach the ground for most of the day.

A few species, especially the water oaks, will germinate in very dense patches in temporary shallow pools of water beneath a complete canopy, but the seedlings invariably die within 3 years unless they are released. Others, like the ashes and the other oaks, germinate sparsely and develop for some years as scattered individuals in partial light in small openings. But without release they dwindle away before reaching pole size. Release of such advance reproduction is often one of the chief benefits of removal of the overburden.

Water, standing or moving, prevents establishment of reproduction whenever it submerges seedlings during their active growing season. While dormant, the species native to sites subject to flooding are very little affected, even when completely under water. If they are submerged in advance of the growing season, some will stay dormant longer than usual and will begin growth after the water goes down. It appears that cypress at least will endure in this manner far into the growing season. After the buds open, no species but willow can stand having its foliage submerged for more than a few days.

The frequency, depth, and duration of flooding chiefly determine the restocking of lowland areas. Regeneration will probably fail if floods regularly occur during the growing seasons at shorter intervals than are required for seedlings to grow above the average depth of inundation. In some places, floods will prevent establishment of

some species but recede in time to favor species which leaf out late. This, probably more than any other factor, accounts for the location and development of the cypress-tupelo and overcup oak-bitter pecan types.

Shallow water every year can be as detrimental as deep water less frequently, and may be more selective as to species, probably accounting for the cypress-swamp blackgum type. In swamps where water usually stands throughout the growing season, regeneration will be delayed until a rare year or succession of years occurs when conditions are favorable for establishment. The backwater basins, being the most frequently flooded areas after the swamps, are nevertheless among the driest in fall and are especially subject to widespread fires. A burn results in a reversion to buckvine rather than tree reproduction, because buckvine has superior sprouting capacity and tolerance to flooding.

Any cattle grazing is more or less incompatible with hardwood regeneration, and, in the smaller bottoms especially, cattle have been a major influence in preventing hardwood regeneration. Very light grazing, comparable to a normal stocking of deer, might not be serious, but the best practical advice is not to allow grazing except in very special controlled situations.

Hogs probably are of more benefit than harm to regeneration, except where conservation of oak mast is urgent. There is a possibility, still untested, of using cattle or goats to eradicate buckvine and other ground cover detrimental to regeneration.

On the great bulk of the forest, the soil itself has little bearing on reproduction. Where coarse, loose sand lies at the surface or under a thin veneer of fine material, however, trees will fail because the summer water table is normally too deep to deliver moisture through the sand. Such sites are limited in area. They are important probably only in the Mississippi Delta, principally between the levees.

The very fine-textured clay soils of the lowest backwater flats and occasional hardpan basins of the terraces generally have sparser stands than more porous sites and remain bare longer except for the typical thickets of poor willow ("pin") oak on the latter sites. Because of the texture of the soil, the fertility and moisture on these sites are unfavorable for reproduction except of willow oak on the terraces.

Similar soils with better elevation or subsurface conditions accumulate enough organic matter to crumble nicely when exposed to air, absorb and release moisture freely, and provide enough nitrogen for most plants. When these soils are cleared and cultivated, or overrun by repeated hot fires and exposed to the sun, the humus disappears and the sites become dry and puddled to rock-like hardness, incapable of

growing anything but weeds like goldenrod, at least for many years. Locally these are known as "buckshot" soils, and they have little immediate promise for forest regeneration. This is a very particular and relatively limited condition.

The most serious cause of inadequate reproduction is fire. A fire on any given area every 10 years will prevent its restocking to good trees. Prescribed burning has no place in bottomland regeneration.

Regeneration in Specific Types

The foregoing remarks apply broadly to all bottomland types, but a few types and variations of types have peculiarities that require brief description.

Cottonwood and willow

Cottonwood and willow demand absolutely bare, moist, mineral soil for germination and for at least the first few weeks of growth. Even light, low, ground cover competition, especially sod, greatly hampers growth. At no time will these species tolerate any overhead shade, even from weeds. They will, however, endure long flooding and silt deposition, though only willow survives complete inundation during the growing season. Cottonwood and willow stands are normally extremely dense and development is very rapid, averaging 5 feet of height growth per year for 10 to 15 years. Cottonwood asserts dominance promptly, allowing the better trees to get ahead, but willow stagnates early.

Site clearing and ground scarification would be necessary to make either species succeed itself, and even then success would further depend on appropriate flood stages or an unusually rainy summer. Usually it is preferable to allow mixed riverfront hardwoods to come in as the natural succession to cottonwood and willow. Generally the only work needed to secure a good stand of mixed hardwoods following cottonwood and willow will be eradication of box elder, large vines, and sound cull hackberries, elms, and pecans as they develop under the cottonwood.

Cypress-tupelo

This type will regenerate only in swamps where all competition is eliminated and ground cover is limited to annual herbs.

Regeneration is seriously hampered by three factors. The first of these is fire. When the swamps dry out, the rank vegetation burns furiously, and the species themselves are unusually

vulnerable to fire damage. The second obstacle is the tendency of cut-over swamps to fill up with planer tree, buttonbush, and similar shrubs.

The last obstacle is water. No seeds can germinate under water. Cypress submerged while still dormant will remain dormant far into the normal growing season. When the high water customarily lasts far into the summer, early growth will be extremely slow. After the tree has grown above normal high water, however, it will develop rapidly if fire and competition are eliminated. A copious seed supply is essential to offset the hazards of submergence. A few days' submergence while the tree is in leaf is fatal.

Tupelo and blackgum are a trifle less demanding than cypress. As soon as high water goes down, they leaf out and rapidly run up an unbranched shoot, which gets above high water stages within two or three growing seasons. In shallow swamps, regeneration of these two species is fairly sure and prompt, barring fire and competition. In deep swamps, however, even with protection, site clearance, and ample seed, regeneration depends on water stages so low that they may occur many years apart. The shallow but relatively permanent coastal swamps pose an essentially similar problem for which there seems to be no solution but time and an ever-ready seed supply or else artificial control of water stages.

Like cottonwood and willow, this type is typically even-aged by species, and distribution of stands of any given age class within the swamp is often governed or arranged by water depth or contour. These conditions result in distinct two- or even three-storied effects by groups.

Overcup oak-bitter pecan

This type takes over backwater flats and sloughs commonly flooded for a few weeks after the general growing season begins. Because its principal species, including persimmon and green ash, remain dormant and leaf out a month or so later than most species, they endure submergence better. It is lack of competition rather than affinity for these sites that brings them in. Given the chance, they do better on sites with superior drainage and soil texture.

The effects of floods and the manner in which seed collects on low spots as water recedes make reproduction spotty and periodic at best. Except on the very lowest sites, where buckvine does not normally occur, there is great risk of developing a hopeless mat of buckvine through delayed regeneration coupled with fire. Successful regeneration depends on complete fire protection and improvement cutting to the greatest extent consonant with saving an adequate source of seed.

Sweetgum variation and white oaks variation

These variations (of the sweetgum-water oaks and the white oaks-red oaks-other hardwoods types respectively) were common in the virgin forest, but seem unlikely to reproduce naturally even in the rare situations where they still remain. Regeneration would require almost complete opening of the stand, prolific local seedfall, and absolute control of fire and grazing. Generally the most satisfactory course may be to let the main type reproduce in its own fashion and then develop high proportions of these species by favoring them in the course of harvest cutting and stand improvement.

Early Development of Reproduction

Given a seed source and freedom from fire, most openings in the hardwood forest will regenerate. The sunlight that is necessary for seedling growth, however, also induces a jungle of weeds, vines, briars, and brush so thick that individual desirable trees, though numerous, must be searched for amongst the welter.

Such brush-patch beginnings are typical of most bottomland species and forest types. Unless the seedlings are thick enough to form a complete cover in themselves, they apparently must use the jungle as a nurse crop. The need seems to be for enough low cover to prevent baking or puddling of the soil, or the formation of sod.

Close examination of the average brush patch will reveal seedlings and small saplings in numbers between a few hundred and two or three thousand per acre. Many of these young trees will be seemingly overwhelmed by ground cover, as many as two-thirds may be of undesirable species, and half may be crooked, forked, bushy, or suppressed.

Nevertheless, within a few years after the area appears the most hopeless, a very promising stand of saplings emerges and the jungle melts away under its shade. Such sapling stands generally contain between 400 and 1,200 well-established trees per acre, the majority dominants and codominants of desirable species and form. At this stage, moreover, the better species and the best-formed trees tend strongly to grow the most vigorously and to assert dominance, and hence to suppress many of the undesirables.

This is not to say, however, that if fire is kept out optimum growing stock is assured. If left to nature, the resulting pole stand will often fall considerably short of realistic possibilities; much productivity will be wasted on inferior stems. Nearly always a release and cleaning will be highly desirable at the small pole stage, when products may be merchantable or useful for cordwood, posts, or mine props.

PLANTING

The dependability of natural regeneration makes planting largely unnecessary. This is fortunate, for it would be difficult and costly in the bottomlands. To date very little is known about planting any tree but cottonwood. Except for this species, which can and should be planted on adaptable sites, no field-scale planting can be recommended at the present time.

STABILIZED MANAGEMENT

For the first managed cut, no detailed plan for regulating the amount of cut on the property as a whole, or on individual compartments, is essential. Before a second cut is made, however, a management plan should be prepared. It may not be very intensive or rigid, but it should systematically cover the property with a budgeted cut. From the preliminary survey and the experience of the first cut, the establishment of compartments should be made final. From an inventory of these compartments and from other data, the possible yields, consistent with growth estimates and long-period management plans, can be estimated. All supporting data and instructions for cutting and other operations should be incorporated into the management plan.

As few bottomland forest tracts are ready for more than the first managed cut, the technics and problems of stabilized management have only secondary significance at this stage. Hence the subject is treated very briefly. But as all forest managers will ultimately have to make a management plan, they should not overlook it in their early planning. The following discussion describes some of the considerations involved in taking the inventory, determining growth, yield, and ideal stocking and stand structure, and calculating the cutting budget.

MANAGEMENT INVENTORY

Each compartment or logging unit should be inventoried before any major part of a growing season has elapsed after the first managed cut. A dependable and efficient system of records for inventory, cutting, and logging data should be developed. Reinventory of each compartment at the time of the next cut will show the net increment between the two cuts. If carefully planned, such an estimate of growth is at least as convenient and economical as any other.

Inventory Information Needed

A statistically sound sampling system should be used in making the inventory of the cut-over stand. It will be satisfactory if the accuracy of the total saw-timber estimate by compartments is within 5 or 10 percent.

All trees which contain at least one tie-and-timber log should be classed as saw timber and so tallied. Trees with only local-use logs should be tallied as sound culls. The local-use logs in tie-and-timber or better trees should be included in the estimate for these

trees. For trees that are classed as saw timber, the grade of the logs to be expected from them should be obtained from a separate study of grade. The percentage of the various grades found in the separate study can be applied to the total sawlog volume estimate.

The proportion of the total saw-timber stumpage which will be salable will vary with time, place, and component grades. The distribution of inventory by species, grade, and diameter must be known if merchantability, utility, or value comparisons are to be made at different times or places. It is advisable also to maintain the original criteria separating undesirable and desirable growing stock (cut and leave) as a check upon the progress of the stand under management.

The inventory data should include:

1. Saw-timber-size trees by diameter, species, log length, and grade: segregated into desirable growing stock and overburden, with overburden divided into undesirable growing stock and culls.

2. Trees under saw-timber size but larger than 5 inches d.b.h., by species and diameter: segregated into desirable growing stock and overburden.

3. In situations described later, growth data from increment borings.

4. Notes on presence or absence of reproduction; problem areas to be located on the maps. No data are needed unless a separate tally of overburden to be removed in site preparation is desirable.

The data should be collected and compiled by types and stand classes. During the inventory, the rough type and stand classification map prepared in the preliminary survey should be checked and corrected in line with the effects of the cutting.

A network of permanent sample plots to be remeasured regularly can be used in lieu of standard repeated forest surveys as a means of keeping track of stand changes and growth. Such a system has real merit and should be given consideration in applying advanced forest practices. A system of permanent sample plots has not been used to any great extent, so there is little experience on which to base detailed recommendations. Enough is known, though, to be sure that skilled hands can make the system work.

Some Inventory Methods

Both the field and office work of obtaining and keeping the inventory are complicated, but realistic management needs the information. There are several ways to accumulate the data. A few popular technics are outlined here.

Plots, located either at random or in line, are preferred to strip sampling, both for efficiency in recording data and to facilitate checking the cruising and the computations.

The preview of the area which was obtained in the preliminary survey should be the basis for planning the intensity of sampling for all phases of the work. A 10 percent sample of the stand used to be conventional, but generally some lesser sample will suffice. The precision needed depends on the area, density, value, and variation of the stand. In most cases, the sampling prescription is calculated in terms of number of plots. Given an estimate of the variation within a stand and a standard of precision desired, the requisite number of plots can be derived by common statistical procedures. Good results, especially from a minimum of sampling, depend on freedom from bias in all measurements, consistent classification, and accurate computation.

For cruising purposes, circular 1/5- or 1/4-acre plots are appropriate for saw-timber trees larger than 17 inches d.b.h. For small saw timber in trees 11 to 17 inches d.b.h., a concentric plot of 1/10 or 1/20 acre is adequate; the exact plot size depends on the density, variation, and value of this group of trees. The non-saw-timber stand, including culls of all sizes, can generally be sampled adequately on a 1/10- or 1/20-acre plot. Large saw-timber trees should be classified as to species group, desirable growing stock or overburden, d.b.h., and merchantable length. The classification should be by 2-inch diameter classes and to the nearest 8 feet of merchantable length. Small sawlog- and other trees should be classified in 2-inch d.b.h. classes as to species group, desirable growing stock, or overburden.

In addition, an estimate of log class and grade should be obtained by taking subsamples in an unbiased manner. The technic must be developed at the time of the survey. The average volume per tree for small saw-timber and non-saw-timber trees should be obtained by sampling. This information, applied to the tree count, will estimate the volume for these groups. Growth data from increment borings should be obtained from the same trees sampled for log class and grade for large saw timber and those sampled for volume in the smaller classes.

Sound cull and undesirable growing stock trees 7 to 11 inches in d.b.h. should be subsampled for short logs and bolts where these are salable.

Tallying of species and later computations can be greatly simplified by treating the species in logical groups. Data on sample trees for estimating grade of saw-timber-size trees and volume of under-saw-timber-size trees, and for making growth determinations, should be kept separate by individual species. These data can be used to approximate the detailed species distribution if it is desired, even though species groups are used elsewhere.

The following groups combine species which have form-class, silvical, or utilization characteristics in common. Added to some groups are rather rare species which occur too infrequently to justify separate tally. Some groups are made up of species of dissimilar characteristics. A tally recorded by type, though, will show which species are actually involved, because the dissimilar ones do not grow together. The grouping is merely suggestive and should be freely adjusted as local circumstances dictate. In application, these groups will automatically be condensed because of the limited range in site (and accordingly in species) within a given area.

A.
1. Sweetgum
2. Cottonwood
3. Willow
4. Sycamore
5. Blackgum
6. Magnolia
7. Yellow-poplar

B.
1. Cherrybark oak
2. Southern red oak
3. Northern red oak
4. Black oak
5. Water oak
6. Willow oak
7. Nuttall oak
8. Shumard oak
9. Laurel oak
10. Diamondleaf oak
11. Pin oak

C.
1. Cow oak
2. Delta post oak
3. White oak
4. Bur oak

D.
1. Overcup oak
2. Post oak

E.
1. White ash
2. Green ash

F.
1. American elm
2. Hackberry
3. Sugarberry

G.
1. Bald cypress
2. Pond cypress
3. Red maple
4. Silver maple
5. Box elder
6. Water tupelo
7. Swamp tupelo
8. Water locust
9. Sweet bay
10. Swamp cottonwood

H.
1. Cedar elm
2. Winged elm
3. Water hickory (bitter pecan)
4. Sweet pecan
5. Hickory
6. Honeylocust
7. River birch
8. Beech

I.
1. Persimmon
2. Sassafras
3. Red mulberry
4. Black walnut
5. Holly

J.
1. Loblolly pine
2. Spruce pine

K. Weed species: tally all weed species merely as sound culls.

Computations

For the customary compilation of area, volume, and stand tables, any standard technique used in assembling forest inventory will yield satisfactory results.

One method of breaking the total saw-timber estimate down by log grade is that used in the South by the U. S. Forest Survey. Each 16-foot section (or terminal 8-foot section) in standing sample trees is graded in the field according to the grade of the best 12-foot section it contains. Cull deductions may be indicated log by log in percent. The net volume of each section is then computed by means of Mesavage and Girard's table of percentages of total tree volume represented by logs in consecutive positions in the stem.10/

Securing volumes for non-saw-timber trees requires subsampling enough tapers and lengths to enable construction of local diameter-class tree volume tables by groups of species. Alternatively, it may be convenient to accept the bias of ready-made volume tables such as the Mesavage form-class cubic-foot tables. If the latter tables are used, they may tend to give low estimates for all except such species as cottonwood, willow, sweetgum, tupelo, and yellow-poplar in dense stands.11/

Topwood Estimates

Because of lack of available markets, there is no substantial need in the bottomlands for measurement of topwood, but since it makes up about 40 percent of the total cubic volume of saw-timber trees, it is often desirable to have some estimate of it. The cheapest method is to sample, during a timber-cutting operation, the ratio of cubic cordwood volume in tops to log-scale volume. The ratio varies with species, tree size, and form, but usually averages from 1 to 1-1/2 gross cords of topwood per thousand board feet (Doyle) in stems. The ratio is greatest in timber of small diameter and with short boles.

10/ Mesavage, Clement, and Girard, J. W. Tables for estimating board-foot volume of timber. U. S. Dept. of Agr., 94 pp., 1946. For sale by the Superintendent of Documents, Washington, D. C., 20 cents per copy.

11/ Mesavage, Clement. Tables for estimating cubic-foot volume of timber. Southern Forest Expt. Sta. Occasional Paper 111, 71 pp. 1947.

GROWTH DETERMINATIONS

Data on growth and increment can be obtained by comparing data from successive inventories. Until a second inventory has been finished, however, a crude estimate of growth may be made by stand table projection.[12] The increment borings previously suggested will be used for this purpose. The great weakness of such a method is ignorance of mortality and acceleration or deceleration of growth. If growth percents from comparable stands are available, they can be used to give an approximation of growth, thus providing another approach to this problem.

There is a question as to how to handle growth estimates for areas which still support excessive volumes of overburden after the first managed cut has been made. Obviously, the second cut in such stands should be on essentially the same basis as that generally prescribed for the first managed cut. Nevertheless, in the interest of calculating the cutting budget under stabilized management, such stands must be considered. The allowable cut should therefore be calculated from the increment on the growing stock, and to this increment should be added any operable held-over overburden. The held-over overburden should not be included in any calculations of growth--it is merely surplus to be disposed of as quickly as possible and with minimum influence on management plans for desirable growing stock.

A detailed, hypothetical estimate of stand development and growth may occasionally be needed in analyzing the forestry possibilities of a tract. The data from increment borings obtained in the inventory should be used. Growth should be computed for the desirable growing stock separately, in which case neither mortality nor cull need be a serious consideration. Growth of overburden can either be disregarded or it can be projected according to pertinent increment borings, adjusted as to cull and anticipated mortality. The increment data should be adjusted for expected acceleration if cutting is anticipated or deceleration if competition is slowing down growth and cutting is not anticipated. Deceleration can be estimated by projecting the trend indicated by borings made in the particular stand. The degree of acceleration can be estimated from increment borings in trees that have been released in similar stands.

12/ Wahlenberg, W. G. Methods of forecasting timber growth in irregular stands. U. S. Dept. Agr. Tech. Bul. 796, 56 pp., illus. 1941.

STOCKING AND STAND STRUCTURE

The volume in practically all stands after the first improvement cut will be far below the optimum. To allow a margin for safety and build up growing stock, therefore, succeeding cuts should be kept as far below growth estimates as the circumstances of the owner and operating requirements permit. From a strictly silvicultural standpoint, a second cut should be made only when stocking increases enough so that thinning and salvage are required. As the stands approach the structure and density of those outlined in table 3, larger proportions of the increment can safely be cut, until the point is reached where the cut should remove all increment accumulated during the cutting cycle. Periodic cuts at 10 years apart are a good round figure to aim at, but the interval will reasonably vary from 7 or 8 to 15 years. The silvicultural ideal may have to be compromised with business requirements and operating conditions that may dictate adjusting the cutting to either side of the desirable time.

Areas with non-merchantable stands will have to be carried without conventional treatment until an operable stand develops. As soon as one does develop, it can be worked as recommended previously for the first managed cut.

Stand development should be directed towards production of large, high-class, high-grade trees. When the ideal is approximated, the stand will contain as many as possible of the larger sizes and as few trees of the smaller sizes as is consistent with the need for maintaining a balanced growing stock in terms of size; that is, enough, but only enough, of the smaller sizes to furnish a reserve from which to recruit replacements for the larger sizes as they are harvested. Cutting of healthy and vigorous trees should be so timed as to avoid any needless sacrifice of high-yielding investment value by premature conversion to current income, or any sacrifice of earnings by deferring cutting too long. Such timing requires close financial calculations. In fully developed, intensively managed stands, trees 28 to 32 inches d.b.h. will be the usual mature sizes on reasonably good sites, with larger trees occurring commonly. Some 36-inch or larger trees may be grown for special products like face veneer.

Theoretically, the possible cut in the ideal stand as presented in table 3 simply serves to set the stand back to exactly the shape in which it began the cycle. If the surplus trees of the smallest sizes are not cut, most of them will die before doing any harm. Surplus trees above 6 inches should be cut if best results are desired.

Table 3.--Optimum stocking per acre, uneven-aged bottomland hardwoods on good site 1/

D.b.h. (inches)	After cutting; beginning of new cycle		Midway of cycle or average stand		End of cycle; ready for cutting		Cut	
	Trees	Volume	Trees	Volume	Trees	Volume	Trees	Volume
	No.	Cords 2/	No.	Cords 2/	No.	Cords 2/	No.	Cords 2/
2	26.0	(3/)	36.0	(3/)	36.0	(3/)	...	(3/)
4	17.2	0.2	20.0	0.3	30.0	0.4	12.75	0.2
6	10.5	.4	13.0	.5	15.8	.6	5.28	.2
8	8.2	.6	9.7	.7	12.2	.9	4.05	.3
10	7.0	.8	7.6	1.0	9.0	1.2	2.02	.4
12	7.0	1.3	6.8	1.2	7.1	1.3	.10	(3/)
Total	75.9	3.3	93.1	3.7	110.1	4.4	24.20	1.1
		Bd. ft. Doyle		Bd. ft. Doyle		Bd. ft. Doyle		Bd. ft. Doyle
14	6.5	338	6.2	322	6.0	312	...	...
16	5.3	503	5.6	532	5.7	541	0.40	38
18	4.3	632	5.3	779	5.6	823	1.30	191
20	3.2	688	4.3	925	5.3	1,139	2.10	451
22	2.3	678	3.2	944	4.3	1,268	2.00	590
24	1.6	524	2.3	897	3.2	1,248	1.60	724
26	1.1	561	1.6	816	2.3	1,170	1.20	609
28	.8	524	1.1	721	1.6	1,048	.80	524
30	.45	369	.80	656	1.1	902	.65	533
32	.27	272	.45	452	.8	804	.53	532
34	.11	139	.27	329	.45	547	.34	408
36	.04	57	.11	165	.27	392	.23	335
38	.02	28	.04	64	.11	191	.10	163
40	...	...	.02	34	.04	76	.04	76
42	...	...	...	...	.02	37	.02	37
Total	25.99	5,313	31.29	7,636	36.79	10,498	11.31	5,211
All trees	101.89	...	124.39	...	146.89	...	35.51	...
Pct. of full stocking	58.0		72.6		93.0		35.0	

1/ A cutting cycle of not less than 10 years is assumed.
2/ 128 cubic feet, gross, with 75 cubic feet assumed as the net content of wood from 4-inch trees and 80 cubic feet assumed from 6- to 12-inch trees. Topwood in saw-timber trees disregarded.
3/ Negligible.

If management is skillful and intensive for several cutting cycles, those types inherently amenable to selection management, as most bottomland types are, should gradually assume their proper structure and build up to and stabilize at approximately their optimum stocking.

The rate at which management achieves this goal will necessarily vary with a multitude of factors such as existing stand class, type and site, markets, rate of cutting, and stand improvement work. The species distribution in the ideal stand will vary with site but should be manipulated to develop the best integration of stumpage values and growth rates. Choice of individual trees to cut under intensive management will be based on criteria used in the first managed cut.

CUTTING BUDGETS

As a basis for estimating the cutting budget for the first cutting cycle after the initial managed cut, comparison of the original inventory data with that of the reinventory, supplemented where necessary with growth estimates obtained by stand projection, will show the volume of timber with which the manager will have to work during the cutting cycle. For the second cutting cycle and those to follow, increment as well as volume will be obtained by the repeated inventories and the cutting budget determined in relation to it as appears most wise under the circumstances.

What portion of the growth or increment should be reserved from cutting at any one time in the interest of building up growing stock must be left to the dictates of policy harmonized with good forestry practice. There are no technical data to indicate the maximum portion of the growth which could be cut in understocked stands from the standpoint of sound forest management. Ideally, of course, all increment in desirable growing stock should accumulate until the stand reaches full and optimum stocking. Economically, this may not be wise or even possible. The only guide will be firm judgment, operating on the general premise that until the optimum is reached as much volume should be added to growing stock during each cutting cycle as economic and silvicultural realism permits.

FORESTRY POTENTIALS IN THE BOTTOMLANDS

The potentialities of the southern bottomland types are tremendous. These types now occupy about 30 million acres, and despite inroads by agriculture and other factors a minimum of 25 million acres of this land will remain permanently in forest. Under management much of this land will grow 500 board feet (Doyle) of excellent hardwoods per acre per year. In addition, two-thirds of a cord per acre per year can be produced from topwood and small trees which should be removed for cultural reasons. In short, the bottomlands are a large and productive region.

Thus far, very little of the bottomland area has been placed under management. Growing stock is depleted, and depletion is continuing. In one sense, this means that the forestry opportunities are unlimited because the field is wide open. In another sense, the forestry future is harsh because profitable operations following sound silvicultural principles are difficult where depletion is far advanced.

There is ample evidence and example, however, to indicate that aggressive interest and action in forestry can be well rewarded within a period of time acceptable to most private enterprise. The time has come, therefore, to get off dead-center on bottomland forestry and make it a reality. It is bound to spread as it gains a foothold, because it is too good to pass by.

Although the factory lumber from bottomlands has long been in high demand, there remains a large volume of lower grade material for which markets are limited or lacking. Unquestionably, there will be some expansion of markets brought about by human ingenuity and scarcity. Everything possible should be done to encourage expanded markets, for the main key to intensive bottomland forestry is the development of utilization opportunities for low-grade material.

In no broad area in the United States does the forester have the opportunity and at the same time the challenge that exists in the bottomlands. Now is the time to take hold of these opportunities and to accept the challenge which they offer.

APPENDIX

FOREST TYPES RECOGNIZED IN THIS BULLETIN WITH CORRESPONDING TYPES RECOGNIZED BY THE SOCIETY OF AMERICAN FORESTERS[1]

Types of the text	S.A.F. types covered by types of the text	Remarks
Sweetgum-water oaks	82. Redgum	
	83. Redgum-Nuttall oak-willow oak	
	84. Willow oak	
	86. Oak-elm-ash	When water oaks predominate with green ash.
	87. Southern cypress-hardwoods	When cypress is secondary and sweetgum-water oaks are predominating hardwoods.
White oaks-red oaks-other hardwoods	80. Hickory-swamp chestnut oak-white oak	
	81. Redgum-swamp red oak	
	86. Oak-elm-ash	When red oaks or white oaks predominate with white ash.
	70. Loblolly pine-southern red oak	Very limited and very small areas in the bottomlands.
	71. Loblolly pine-white oak	Same as above.

1/ Society of American Foresters. Forest cover types of the eastern United States. Ed. 3, revised, 39 pp. 1940.

Types of the text	S.A.F. types covered by types of the text	Remarks
Hackberry-elm-ash	85. Sugarberry-elm	
	86. Oak-elm-ash	When elm and ash are predominate.
	87. Southern cypress-hardwoods	When cypress is secondary and hackberry, elm, and ash predominate.
Overcup oak-bitter pecan	89. Overcup oak-water hickory	
	87. Southern cypress-hardwoods	When cypress is secondary and overcup oak and bitter pecan predominate.
Cottonwood	61. Cottonwood	
Willow	88. Willow	
Cypress-tupelo	94. Southern cypress	
	95. Tupelo gum	
	87. Southern cypress-hardwoods	When cypress predominates over the hardwoods.
Riverfront hardwoods	59. River birch-sycamore	
	60. Silver maple-American elm	
	85. Sugarberry-elm	When sugarberry and elm are mixed on riverfront lands with other species such as sweet pecan, sycamore, and boxelder.

IMPORTANT BOTTOMLAND SPECIES

These species, for one reason or another, attain importance in the bottomlands of the South. Recognized common names and scientific names are according to "Check List of the Native and Naturalized Trees of the United States, including Alaska." U. S. Forest Service, Washington, D. C. 325 pp. Rev. ed. 1944. Comparative growth rate is average diameter increase in 10 years (for dominant and codominant trees on average or better sites) as follows: Poor—less than 2 inches; medium—2 to 3 inches; good—3 to 4 inches; and excellent—better than 4 inches. Comparative tolerance is based on a general scale in relation to all American species. When factory lumber is listed as a primary use, it automatically implies the myriad of uses into which hardwood lumber is remanufactured.

Recognized common and scientific names	Other common names	Occurrence in the bottomlands	Comparative growth rate	Comparative tolerance	Reproduction	Susceptibility to damage	Primary uses	Remarks
				WHITE OAKS				
White oak (*Quercus alba* and var. *latiloba*)	Forked-leaf white oak	Widely on well-drained soils of oldest terrace and colluvial sites.	Poor to medium	Intolerant	Adequate in openings wide enough to let direct sunlight to ground.	No special problems	Face veneer, tight cooperage, factory lumber, ties and timbers.	Broad utility and high value. Prized both for commercial and farm use; a clean, healthy tree; easy and safe to grade. Not primarily a bottomland species.
Cow oak (*Q. prinus*)	Swamp chestnut oak, swamp white oak, basket oak	Widely on best well-drained loamy first bottom ridges, but principally on well-drained silty clay and loamy terrace and colluvial sites.	Medium to good	Moderately intolerant	Easily obtained in openings but sparse because mast is highly palatable to animals. Sprouts efficiently.	No special problems	Essentially same as white oak, but coarser grain and wider sapwood due to rapid growth are slight handicap for face veneer and tight cooperage.	Same as white oak except that cow oak is typically a bottomland species.
Delta post oak (*Q. mississippiensis*)	Post oak, yellow oak	Mississippi Delta only. Well-drained silty clay and loamy terrace sites. Rarely in first bottoms.	Medium	Moderately intolerant	Easily obtained with light but seldom prolific.	No special problems	Same as cow oak.	Wood has distinct yellow-tan cast requiring separate handling as face veneer. Same as cow oak, otherwise.
Post oak (*Q. stellata*)	...	Widely on most matured terrace and sandy colluvial sites. Usually on poorer soils.	Poor	Moderately intolerant	Easily obtained with light. Sprouts freely.	Commonly infested with spot or flag worm and with grubs on poor sites.	Factory lumber at low value. Good tie and timber species.	Third-rate tree. Natural pruning of upper stem is slow, trees generally short. Good farm-use species. Hard to grade because of spot worm. Not primarily a bottomland species.
Overcup oak (*Q. lyrata*)	Swamp post oak, swamp white oak	Widely on the lower poorly drained sites of both first bottoms and terraces of the larger streams. Scattered on better sites. Prevalent in sloughs and backwater areas.	Very variable but generally medium	Moderately intolerant	Prolific but often killed by high water during growing season. Starts readily in either open or shade but soon dies in shade.	Insect damage very common. Especially liable to mineral stain and heart check.	Utility extremely variable with site and fire damage. At best equivalent to white oak. Frequently worthless for factory lumber because of stain and insects. Checking during seasoning prevents use for ties and timbers.	Poor second-rate species. Next to post oak, the poorest of the white oaks. Log grades determined mainly by insect damage and heart check.
Bur oak (*Q. macrocarpa*)	Mossy cup oak, burr oak	Only in north part of Mississippi Delta and western stream bottoms on wetter sites in either first bottoms or terraces.	Variable but generally medium	Moderately intolerant	Prolific in open areas but often killed by high water during growing season.	No special problems	Ties and timbers; factory lumber. Generally higher quality than overcup oak because free of insects.	Hard, strong, and durable wood; excellent farm-use species. Second-rate species commercially because of roughness.

Recognized common and scientific names	Other common names	Occurrence in the bottomlands	Comparative growth rate	Comparative tolerance	Reproduction	Susceptibility to damage	Primary uses	Remarks
				RED OAKS				
Southern red oak (Quercus falcata)	Swamp oak, red oak	Widely on older terraces and colluvial deposits. Drier sites.	Medium	Moderately intolerant	Easily obtained with light.	Readily susceptible to insects and disease when wounded or growing on poor sites.	Ties and timbers. Best trees produce factory lumber logs.	Second-rate tree because of tendency to roughness and insect and stain damage. Not primarily a bottomland species.
Cherrybark oak (Q. falcata var. pagodaefolia and leucophylla	Swamp red oak, bottomland red oak, red oak	Widely on best loamy sites in first bottoms and on most well-drained terrace and colluvial sites.	Good to excellent	Intolerant	Easily obtained with full light. Sprouts fairly efficiently.	No special problems except tendency to ant infestation when overmature or injured on poor sites.	High value. Face veneer, factory lumber, cross ties.	Best red oak. Rapid growth and high-quality wood of general utility. Safe and simple to grade.
Shumard red oak (Q. shumardii)	Striped oak	Restricted to good loamy ridge soils on terrace or colluvial sites. Rarely on first bottoms. Widely distributed but very scattered.	Good	Intolerant	Easily obtained in full light.	Same as cherrybark oak.	High value. Face veneer, factory lumber, cross ties.	Quite similar to cherrybark oak in utility but more selective as to site. A poor variety of this species (schneckii) grows in the uplands.
Black oak (Q. velutina)	Yellow butt oak	Widely scattered on oldest or most matured terrace and colluvial sites. Drier sites.	Medium	Intolerant	Fair but erratic.	Greater than average susceptibility to disease and insects on poor sites.	Ties and timbers. Factory lumber from better trees.	Poor second-rate tree, often very poor. Best trees, on best sites, equivalent to cherrybark oak. Not primarily a bottomland species.
Northern red oak (Q. borealis)	Red oak	Only in northern two-thirds of Alabama and Mississippi, excluding Delta, on well-drained terrace and colluvial sites.	Medium to good	Moderately intolerant	Fairly easy to obtain	No special problems	High value. Face veneer, factory lumber, ties and timbers.	Excellent tree. Equivalent to cherrybark oak. Not primarily a bottomland species.
				WATER OAKS				
Nuttall oak (Q. Nuttallii)	Swamp red oak, southern pin oak, pin oak, swamp black oak, striped oak	Widely in first bottoms of major streams on flats, low ridges, shallow sloughs, and margins of swamps. Less common on similar sites on terraces of major streams.	Good to excellent	Intolerant	Prolific but often killed by high water during growing season. Starts readily in either open or shade but soon dies in shade.	No special problem for healthy trees on the better sites. On terraces and in backwater areas overmature and damaged trees are subject to insects and mineral stain. Death of mature trees common in case of drought or lowered water table.	Highly acceptable for factory lumber.	Good second-rate tree. Excessive checking in seasoning inhibits use for ties and timbers. Insects and limbiness on poor sites limit higher use.
Pin oak (Q. palustris)	Northern pin oak	Northern part of Mississippi Delta. In first bottoms on wet flats with impervious soil.	Good to excellent	Intolerant	Prolific in openings.	No special problems	Local-use lumber, props, and fuel.	Almost worthless for standard lumber because of knots; excessive checking and frequent large dead knots reduce utility for ties and timbers.

Recognized common and scientific names	Other common names	Occurrence in the bottomlands	Comparative growth rate	Comparative tolerance	Reproduction	Susceptibility to damage	Primary uses	Remarks
				WATER OAKS (continued)				
Willow oak (Quercus phellos)	Pin oak, water oak, black oak, red oak	Widely on both first bottoms and terraces. At best in first bottoms on well-drained low ridges. Satisfactory on terrace flats with well-drained silty clay soils. At its worst in pure stands on hardpan terrace flats.	Generally good to excellent but varies greatly with site. Poor to medium on hardpan flats.	Intolerant	Easily obtained in full light. Sprouts fairly efficiently.	On poorer sites especially subject to insect infestation and mineral stain.	Factory lumber. Ties and timbers principally from terrace stands.	Very important species because of wide distribution, rapid growth, and relatively high utility. On hardpan terraces almost worthless for the better uses because of insect damage, mineral stain, and limbiness. Tendency to check excessively, especially in first bottom timber.
Water oak (Q. nigra)	Striped oak, pin oak, orange oak	Widely on better loamy ridges in first bottoms and on any ridge and silty clay flats in the terraces.	Good to excellent, though very variable.	Intolerant	Prolific in full light. Sprouts fairly efficiently.	Very susceptible to disease and insect attack on impervious and dry terrace soils.	Factory lumber. Ties and timbers from terrace sites. On poorer sites, insect damage, mineral stain, and adventitious knots often make it worthless for higher uses.	A very good second-rate tree on good sites. Knotty, grubby, and stained on poor sites. May check excessively in drying.
Diamondleaf oak (Q. obtusa)	Water oak, spotted oak, obtusa oak	Near Coast on flat, hummocky, wet first bottom sites.	Good to excellent	Moderately intolerant	Reproduces well in small clumps in shallow pools in direct light.	Fairly resistant to insects and disease. After fires or on poor sites, insects, stain, and disease are serious.	Factory lumber, unless too badly stained or insect-damaged.	Second-rate tree. Checks excessively.
Laurel oak (Q. laurifolia)	Water oak, spotted oak, willow oak	Near Coast in wet flats and on margins of swamps. Most common on terraces of minor streams.	Good to excellent	Moderately intolerant	Erratic but plentiful with light.	Commonly insect-infested and stained.	Rarely for factory lumber or ties and timbers.	Knots, grubs, stain, and tendency to check excessively make it about worthless for the present in most situations.
				OTHER SPECIES				
Sweetgum (Liquidambar styraciflua)	Redgum, gum	Wide occurrence on almost all sites. Best and commonest on loamy or clay ridges on first bottoms and on silt loam flats on terraces.	Good	Very intolerant	Very easy to obtain in full light. Sprouts efficiently.	Quite free of insect and disease problems. On poorer sites, tops die as trees mature. Drought or lowered water table leads to serious mortality.	Broad utility and high values. Face, commercial, and box veneer. Factory lumber. Furniture and interior trim. Cross ties, structural lumber, and pulp.	Most important single bottomland species. Usually high-quality; easy to grade given due regard to overgrown knots.
Cottonwood (Populus deltoides)	Southern cottonwood, poplar	Widely distributed but mostly on newly deposited soil along major streams.	Excellent, 6 to 8 inches in diameter in 10 years.	Very intolerant. Cottonwood and willow most intolerant bottomland species.	Reproduces abundantly and quickly but only on wet mineral soil. Sprouts well.	No serious problem unless fire occurs, then very susceptible to decay and mortality.	Factory lumber. Package and commercial veneer. Truck and wagon boxes. Pulp.	Fastest growing tree in North America. Highly prized. Clear wood; light and tough.
Swamp cottonwood (P. heterophylla)	Bigleaf cottonwood, black cottonwood	Widely scattered but only in shallow swamps.	Good to excellent	Very intolerant	Erratic and sparse.	No special problem	Box lumber and package veneer. Pulp.	Rarely associated with P. deltoides, commonly with cypress and tupelo gum in terrace or coastal swamps.

Recognized common and scientific names	Other common names	Occurrence in the bottomlands	Comparative growth rate	Comparative tolerance	Reproduction	Susceptibility to damage	Primary uses	Remarks
				OTHER SPECIES (continued)				
Black willow (Salix nigra and var. altissima)	Willow	Margins of principal rivers of Coastal Plains and Mississippi Delta. Important only on riverfront land.	Excellent	Very intolerant. Along with cottonwood most intolerant bottomland species.	Reproduces profusely but only on bare wet mineral soil. Sprouts vigorously.	No special problem	Production limited to the Mississippi River Delta. Factory lumber, commercial and package veneer, pulp. Interior trim from red heart lumber.	Very fast-growing but short-lived. Will stagnate if not thinned early. Very tolerant of submergence and silting. Outstandingly tall, clear stems.
Blackgum, black tupelo (Nyssa sylvatica)	Hill blackgum	Throughout region on colluvium and terraces with silt loam soils. Prefers well-drained sites but will stand brief spring flooding.	Poor to medium	Intolerant	Sparse	No special problem	Cross ties, factory lumber, pulp.	Rather low value due to great tendency to warp, though can be excellent when large enough for quarter-sawing. Commonly grows with white oaks and hickory.
Water tupelo (N. aquatica)	Tupelo, tupelo gum, swampgum, olive tree, bay poplar, gum	Throughout region but almost exclusively in swamps of the flood plains of alluvial streams.	Medium	Intolerant	Prolific on open, wet soil on proper site	No serious problem	Package and commercial veneer, factory lumber, cross ties, pulp.	Normally in even-aged dense stands, often with cypress but little else. Swollen butts of trees in deep swamps develop punky texture unfit for use. A substitute for sap sweetgum for most uses. Exceptionally clear and defect-free.
Swamp tupelo (N. sylvatica biflora)	Swamp blackgum, blackgum, gum	Non-alluvial coastal swamps from Virginia to Louisiana. Unimportant west of Mississippi River.	Medium	Intolerant	Prolific on open wet soil on proper site	No special problem	Same as N. aquatica but with more stress on veneer. Notable use for small dimension direct from round timber.	Same as N. aquatica. Also associates with sweet bay. Swollen butts not so serious because of shallower swamps.
Green ash (Fraxinus pennsylvanica lanceolata)	Swamp ash, ash	Widely on first bottoms except in deep swamps, but most common on flats. On terraces in flats and sloughs.	Medium	Very intolerant	Prolific in openings. Best on wet sites. Sprouts efficiently.	Very susceptible to fire damage. Cankers with dry yellow heart rot occasionally serious.	High value. Thick factory lumber, handles and athletic goods, vehicle and implement parts.	On low, wet sites commonly develops swollen butt which is brash, thereby reducing utility. Outstandingly clear; easy to grade.
White ash (F. americana)	Cane ash, ash	Widely on ridges and high, hummocky flats on terraces and on colluvium.	Medium	Very intolerant	Prolific in openings. Sprouts efficiently.	No special problems, but very sensitive to fire.	Same as green ash except somewhat preferred for handles and athletic goods.	No problem with swelled butts as in green ash. Exceptionally defect-free; simple and safe to grade.
American beech (Fagus grandifolia)	Beech	Widely in minor stream bottoms, usually on well-drained terrace ridges. Common on colluvial soils.	Poor	Very tolerant	Erratic except in very favorable circumstances.	No special problem	Low value because of "blind" or overgrown knots. Factory lumber and cross ties.	Third-rate tree because of "blind" knots and slow growth. One of most tolerant bottomland trees and tends to eliminate better species from best sites.
American elm (Ulmus americana)	Soft elm, red elm, white elm, water elm	Widely in both first bottoms and terraces except deep swamps. Especially on first bottom flats.	Medium. Good on well-drained flats in first bottoms.	Tolerant	Prolific in openings. Becomes established as an understory. Sprouts vigorously.	No special problem	Factory lumber, slack cooperage and bending stock. Commercial and package veneer.	Good second-rate tree. Tendency towards poor form. Adventitious sprouting and sapsucker attack common but otherwise exceptionally clear.

Recognized common and scientific names	Other common names	Occurrence in the bottomlands	Comparative growth rate	Comparative tolerance	Reproduction	Susceptibility to damage	Primary uses	Remarks
				OTHER SPECIES (continued)				
Cedar elm (Ulmus crassifolia)	Rock elm, southern rock elm, hard elm	Widely in first bottoms on flats and poorly drained, low ridges. Some on terrace flats with tight soil. Restricted to major streams.	Poor	Very tolerant	Scattered. Persists beneath overstory.	No special problem	Local-use lumber. Rarely for factory lumber. Generally low utility for any use.	Third-rate tree, but possesses greater utility than is yet recognized. Extremely hard wood, so cannot be used with other elm. Severe adventitious sprouting degrades upper logs. Fluted, odd-shaped stems common.
Winged elm (U. alata)	Hard elm, rock elm, white elm	Widely on terrace ridges and colluvial sites. Occasionally on high terrace flats with tight silty soils.	Poor	Tolerant	Prolific in openings. Becomes established sparsely as an understory.	No special problem	Sparingly for factory lumber. Local-use lumber.	Too hard for slack cooperage. A relatively small tree of good form. Commonly with blackgum, post oak, and hickory.
Sugarberry, hackberry (Celtis laevigata, C. occidentalis)	Hackberry Hackberry	Widely on first bottoms except deep swamps, most common on flats. On wet flats and in shallow sloughs on terraces.	Poor to medium	Very tolerant	Prolific in openings. Becomes established as an understory.	Once tree is wounded, rot occurs and advances rapidly.	Slack cooperage mostly. A little for factory lumber.	No distinction between these two species. Sugarberry is the common species. Hackberry occurs only in north part of region. Growth rate extremely sensitive to competition. A small tree of poor form.
Hickory (Carya spp.)	Hickory	Widely on terrace ridges and colluvial sites. On high terrace flats with silty clay soils.	Poor	Very tolerant	Prolific. Sprouts efficiently. Develops as an understory.	A borer commonly attacks weakened trees and trees on poor sites. Favored by sap suckers.	Striking tool handles, athletic goods, wagon stock. Very sparingly for factory lumber.	Four true hickories are included and no distinction made. Third-rate species. Only best-quality material used.
Pecan (C. illinoensis)	Sweet pecan	On riverfront lands of Mississippi Delta and along major rivers west of the Delta to Texas.	Good	Intolerant	Scattered but dependable. Becomes established under cottonwood.	No special problem	Factory lumber, athletic goods.	Good tree. Has become established in the trade for flooring and furniture.
Water hickory (C. aquatica)	Bitter pecan	Widely only on low flats, in sloughs and margins of swamps in both first bottoms and terraces of major streams. Greatest concentrations in flats of principal backwater basins.	Poor	Intolerant	Prolific in full light	No special problem. Leafs out late, withstands flooding well.	Factory lumber. Accepted same as sweet pecan when quality permits.	Extreme tendency to ring shake makes it third-rate tree. When free of ring shake, quite acceptable.
Honeylocust (Gleditsia triacanthos)	Honeylocust	Scattered widely on all sites except sloughs and swamps.	Medium	Intolerant	Sparse and unpredictable. Common on old pastures.	No special problem	Local-use lumber, posts, occasionally factory lumber.	Tendency to ring shake and heart check in large, old trees.
Water locust (G. aquatica)	Water locust, swamp locust	Scattered widely in nearly all alluvial swamps, and sloughs and wet flats of both first bottoms and terraces.	Good	Intolerant	Erratic but occasionally prolific in openings in swamps. Sprouts vigorously.	No special problem	Rarely for either factory or local-use lumber.	Third-rate tree: poor form and small size.

Recognized common and scientific names	Other common names	Occurrence in the bottomlands	Comparative growth rate	Comparative tolerance	Reproduction	Susceptibility to damage	Primary uses	Remarks
				OTHER SPECIES (continued)				
Magnolia (Magnolia magnolia)	Magnolia	Mainly within 100 to 200 miles of Coast on oldest terraces and colluvial sites. Principally in minor stream bottoms.	Medium	Tolerant	Erratic and scattered	No special problem	Factory lumber. In strong demand as substitute for yellow-poplar.	Good second-rate tree. Appears rough but cuts out fairly clear lumber.
Sweet bay (M. virginiana var. australis)	White bay, bay	East of Mississippi River in swamps of the Coastal Plains.	Poor to medium	Intolerant	Erratic but occasionally prolific in openings	No special problem	Package veneer, pulp, limited use for box factory lumber.	Scattered distribution and small maximum size limit its use.
Yellow-poplar (Liriodendron tulipifera)	Poplar, tulip poplar	Mainly east of Mississippi River. Only on best well-drained terrace and colluvial sites. Mainly along minor streams.	Excellent	Very intolerant	Prolific on bare soil in wide openings	No special problem. Very susceptible to fire damage. Some mineral stain.	Factory lumber, commercial and package veneer, pulp.	A clean, clear species, highly desired. Greatest general utility hardwood species. Not primarily a bottomland species.
Red maple (Acer rubrum)	Soft maple	Scattered widely in first bottoms except on ridges and in deep swamps. On wet flats in terraces.	Medium to good	Tolerant	Dependable; normally establishes a sparse understory. Sometimes forms thicket in openings.	Mineral stain very common. Spot worm prevalent.	Factory lumber	Scattered occurrence and poor form have limited its use. Valuable when of suitable size and form. Used regardless of spot worm but at depreciated value.
Silver maple (A. saccharinum)	Soft maple	On river fronts in northern portion of Mississippi Delta and along other major streams almost to Coast.	Excellent	Very intolerant	Prolific on bare mineral soil	Spot worm common.	Factory lumber: furniture, trim, flooring, Pulp.	Good second-rate tree. Short-bodied but clear, large size. Substituted for hard maple where texture is not too important.
Boxelder (A. negundo)	Ashleaf maple	Widely on river fronts of major streams.	Excellent	Intolerant	Prolific on bare mineral soil. Reproduces under cottonwood overstory.	No special problem	Very rarely used. Some lumber and crating. Pulp.	Matures when young and small. Very poor form. Practically a weed tree.
Sycamore (Platanus occidentalis)	Plane tree	Widely on fronts of major streams. On banks of minor streams.	Excellent	Intolerant	Prolific on bare mineral soil	Overmature trees subject to ant attack, which causes ingrown bark pockets.	Commercial and package veneer. Occasionally factory lumber. Butcher blocks.	Very large trees likely to be windshaken. Favored veneer species. Especially clean, clear boles.
Black walnut (Juglans nigra)	Walnut	Scattered in northern part of region on the best well-drained loamy sites.	Medium to good	Intolerant	Sparse but dependable; confined to best well-drained soils.	No special problem	Face veneer. Factory lumber for cabinets and interior trim. Gun stocks and other specialties.	Very high value. Not common in the major bottoms.
River birch (Betula nigra)	Red birch, water birch	On river fronts in northern Mississippi Delta and along other major streams, and along banks of minor streams to the Gulf.	Good	Intolerant	Prolific on bare mineral soil	No special problem	Commercial and package veneer. Rarely for lumber. Little used.	Poor second-rate tree. Prevalence of "sugar streak" inhibits use for "face" purposes.

Recognized common and scientific names	Other common names	Occurrence in the bottomlands	Comparative growth rate	Comparative tolerance	Reproduction	Susceptibility to damage	Primary uses	Remarks
				OTHER SPECIES (continued)				
Persimmon (Diospyros virginiana)	Persimmon	Scattered widely on wet flats, shallow sloughs, swamp margins on first bottoms. Similarly but less common on terraces.	Poor	Very tolerant	Sparse but dependable. Occurs in the understory. Sprouts efficiently.	No special problems	Shuttle blocks, golf club heads	Good self-pruning tree. Heartwood valueless because of excessive checking in seasoning, but little heartwood develops on favorable sites.
Red mulberry (Morus rubra)	Mulberry	Scattered widely in first bottoms except in swamps and on dry ridges. On well-drained flats on terraces.	Poor	Very tolerant	Occurs easily from seed and sprouts well. Reproduces in the understory.	Stem canker causes considerable mortality locally.	Fence posts	A small understory tree. Highly prized for fence posts.
Holly (Ilex opaca)	Holly	Very scattered on high terraces and colluvial sites. Principally in minor stream bottoms.	Poor	Very tolerant	Sparse but dependable	No special problems	Decorative foliage and fruit. Special cabinet work in trifling amounts.	Matures at small size, short stems. Wood has negligible commercial demand.
Sassafras (Sassafras officinale)	Sassafras	Scattered widely on any well-drained site. Best on well-drained first bottom ridges.	Medium	Intolerant	Sparse, erratic except for sprouting	No special problem	Boat lumber, rarely interior trim, posts.	No appreciable factor in commerce, though lumber is lightweight, durable, and straight-grained, and works and bends well.
Baldcypress (Taxodium distichum)	Cypress, yellow cypress, red cypress	Widely in swamps, deep sloughs, low, poorly drained flats.	Poor	Tolerant	Erratic, complicated by water and timing of floods. Averages poor but is occasionally excellent.	No special problem. Very old trees are prone to be "pecky."	Factory and structural lumber, boat and tank stock, piling.	Highly prized because of durability, exceptional working qualities and special utilities.
Pond cypress (T. ascendens)	Cypress, black cypress	Shallow swamps and ponds of southern Coastal Plains east of the Mississippi River.	Poor	Tolerant	Erratic. Generally poor.	No special problem but "peck" in overmature trees.	Structural lumber, cross ties.	Smaller and far less important and useful than baldcypress.
Loblolly pine (Pinus taeda)	Old field pine, Rosemary pine	On oldest, well-drained terraces and colluvial sites. Mainly along minor streams.	Good	Intolerant	Reproduction made difficult by hardwood competition, but species is maintaining itself.	No special problem	Structural lumber, pulp.	Not primarily a bottomland species.
Spruce pine (P. glabra)	Rosemary pine, white pine	East of Mississippi River on well-drained, high ridges of first bottoms and better terrace sites of minor streams.	Excellent	Moderately intolerant	Reproduction adequate in small openings on proper site.	No special problem	Structural lumber, pulp.	Rougher than loblolly pine. Occurs only in the bottoms.

Recognized common and scientific names	Other common names	Occurrence in the bottomlands	Comparative growth rate	Comparative tolerance	Reproduction	Susceptibility to damage	Primary uses	Remarks
				WEED SPECIES				
Blue beech (Carpinus caroliniana)	Ironwood	Widely on any well-drained terrace or colluvial site. Mainly on terraces of minor streams.	Poor	Very tolerant	Prolific in openings. Occurs in understory.	...	...	Bad pest where dense enough to exclude other species. Does not reach timber size.
Hophornbeam (Ostrya virginiana)	Ironwood	Same as blue beech	Poor	Very tolerant	Same as blue beech	...	...	Same as blue beech
Planer tree (Planera aquatica)	Water elm	Widely in swamps, deep sloughs, low poorly drained flats in both second bottoms and terraces.	Poor	Moderately intolerant	Occurs easily after cutting or fire.	...	...	Too short and poorly formed for timber use. Bad pest.
Roughleaf dogwood (Cornus drummondi)	Swamp dogwood	Widely on low first bottom ridges and better drained flats, but somewhat indicative of rather poor impervious or dry site.	Poor	Tolerant	Sparse but can largely preempt open areas on appropriate sites.	...	...	Too small and poorly formed for any timber use.
Swamp privet (Forestiera acuminata)	Privet	Widely on wet flats and shallow sloughs in first bottoms.	Poor	Tolerant	Prolific on proper site	...	...	Too small for timber use. Can be a serious pest.
Hawthorne (Crataegus spp.)	Haw	Widely on well-drained flats and ridges of first bottoms, well-drained flats in terraces.	Poor	Very tolerant	Scattered in understory. May make a thicket in openings.	...	...	Too small and poor form for timber use. A moderate pest.
Buttonbush (Cephalanthus occidentalis and var. pubescens)	Buttonball	Widely in deep sloughs and swamps	Poor	Moderately intolerant	Prolific in openings after heavy cutting and fire	...	...	A large bush or shrub which has ruined much swamp site.

SPECIES OCCURRING BUT UNCOMMON IN THE SOUTHERN BOTTOMLANDS

Durand oak (Quercus durandii)
Primarily an upland tree east of the Mississippi River but occurs scattered on well-drained bottoms west of the River. General appearance and characteristics suggest a hybrid between cow oak and either overcup or post oak. Utility similar to cow oak.

Swamp white oak (Q. bicolor)
A northern species that occurs very rarely on the upper fringe of the southern bottomlands.

Basswood (Tilia spp.)
Upland trees that occur rarely on best terrace and colluvial sites. White, tasteless, odorless wood, extremely light and tough.

Pumpkin ash (Fraxinus tomentosa). Scattered throughout on wet flats and in swamps. No practical difference from green ash.

Black cherry (Prunus serotina). Scattered throughout but very sparse on oldest terrace and colluvial sites. Lumber and veneer highly prized for furniture and cabinet work.

Atlantic white-cedar (Chamaecyparis thyoides). Concentrated in swamps of the eastern Gulf Coast and south Atlantic Coastal Plain. Quite similar to cypress in utility.

Florida maple (Acer floridanum) and sugar maple (Acer saccharophorum)
Scattered widely but sparsely in smaller bottoms. Not in the Mississippi Delta.

Osage-orange (bois d'arc) (Maclura pomifera)
Fairly common on small bottoms in northern parts of Louisiana and Texas and south Arkansas and Oklahoma. Very durable wood, highly prized for fence posts. Too small for common use but welcomed for specialties such as insulator pins and archer's bows.

Catalpa (Catalpa spp.)
Sparsely on terrace sites and small bottoms in central Mississippi and Alabama and southwest Georgia. No particular commercial use except fence posts.

Flowering dogwood (Cornus florida)
An upland species that rarely extends to the best and oldest terrace sites. Sought for shuttle blocks.

Southern waxmyrtle (Myrica cerifera)
A shrub of the lower Coastal Plain that frequently fringes and occasionally invades the bottomlands.

FINANCIAL MATURITY OF BOTTOMLAND RED OAKS AND SWEETGUM

By

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This paper offers a method for determining financial maturity of a tree--that is, for deciding when to cut a tree in order to make the most money from growing and harvesting it. The method is illustrated with the sweetgum and bottomland red oaks (Nuttall, willow, water, and cherrybark oaks) found in the Mississippi River Delta and other southern river bottoms subject to periodic overflow.

The idea of financial maturity is this:

Profitable timber management consists in obtaining, and in tapping for harvest, a stand of trees fully-stocked, fast-growing, and of high quality. From time to time, the forest manager visits each acre and marks for removal those trees whose quality or growth rate is below par. Bearing in mind how the typical tree develops --low value at first but rapid increase in value; a gradual slackening in the rate of increase until the stage is finally reached where the tree ceases to pay its way--the manager appraises his trees with the object of putting the ax to those that are reaching this crucial point. This is the point of financial maturity.

The financial-maturity idea can be used, if properly adapted, under any silvicultural system. Here, with bottomland hardwoods as the illustration, the idea is developed with many-aged (individual-tree or group-selection) systems of management mainly in mind. Following is the gist of the method for recognizing financial maturity:

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1. Determine the rate of return that is desired from the money invested in the tree. This rate will usually depend on what could be obtained by taking the money out of the tree and investing it elsewhere. It is called the alternative rate of return.

2. Determine how tree volume and quality are related to tree diameter. Thus, a 22-inch red oak with a grade 1 butt log and a grade 2 second log has a volume of 294 board feet. When it reaches 24 inches, the volume will be 358 board feet and the grade will probably be unchanged.

3. Determine the value of trees according to volume, grade, and diameter, thus making it possible to predict value. For example, the same 22-inch red oak has a value of about $9.56. At 24 inches, its value will be $13.35.

4. Determine reliable rules for judging the vigor of trees as an index of their prospective diameter-growth rate. The appearance of bark and crown of the 22-inch oak indicates, for the sake of the example, that the tree will grow 2 inches in diameter over the next 10-year cutting cycle.

5. Determine the prospective rate of increase in tree value. An increase from $9.56 to $13.35 in 10 years represents an annual rate of 3.4 percent compound interest. If the alternative rate of return is 4 percent, the oak, considered by itself, is financially mature and should be marked for cutting.

6. Determine whether the influence of other trees will affect the financial maturity decision. If there is a mature tree of lower value crowding the 22-inch oak, removal of this lower-value tree may increase the oak's growth to 3 inches in 10 years and its rate of value increase to 4.9 percent. In this case, the oak is financially immature and should be left to grow at least one more cutting cycle if the alternative rate of return remains 4 percent.

In what follows, details of the financial-maturity method are given in order for each of the six steps outlined. After this, some ready-made, simplified marking guides for bottomland red oaks and sweetgum are discussed. The full text is intended for readers who wish to follow the reasoning behind the method or to use the method as a basis for working up marking rules for their particular forest tracts. The reader who is interested more in the bottomland hardwood example than in the method as such may turn directly to step 4. Those whose main interest is in marking guides will find them on pages 23-24.

Step 1 --Alternative Rate of Return

The alternative rate of return against which a tree's rate of value increase is judged in determining financial maturity is a thing peculiar to each forest owner, whether individual or corporate. Some owners have alternative uses for their capital that will yield at a high rate; for other owners, the best alternative may promise but a low yield. Consequently each owner must work out his own alternative rate of return.

An owner's alternative rate may be determined by his opportunities either for investing funds or for spending them. In the case of investment, the rate may be set "by the prospective rate of return on new forest land, on planting or other cultural measures, or simply on the bonds of some borrower in or out of forestry enterprise. For spending, too, the return available from funds is in general expressible. For example, the cost of borrowing tends to determine the premium on funds for meeting business expenses, and individual time preference is similarly determinative in personal consumption....

"In determining the alternative rate of return, there are three noteworthy considerations: (1) Where the rate is based upon the net return from alternative investments, this return must be estimated after income taxes, since funds derived from reinvestment of liquidated timber capital are subject to one more income taxing than are funds taken directly from the timber capital. (2) Where there is more than one alternative rate of return, the highest rate governs. (3) Where the alternative use of funds involves a different degree of risk than is involved in the growing-stock investment, the alternative rate of return must be adjusted to terms of equal risk." 2/

Whatever the rate that is desired, a decision on the matter is essential to any determination of financial maturity. When the forest manager and the owner are the same person, no problem will arise in putting the alternative rate into practice. Where the forest manager is the owner's agent, he must know the alternative rate of return that is desired before he can carry out the owner's policy successfully.

2/ Duerr, William A., and Bond, W.E. Optimum stocking of a selection forest. Jour. Forestry 49: (in press).

Step 2 --Volume and Quality

How to express tree volume and quality will depend on the products for which the trees are being grown. For bottomland red oaks and sweetgum, it is assumed that the goal of the forest manager will be the production of standard factory lumber. Such lumber makes up about 70 percent of total hardwood consumption and represents, in general, the highest use of bottomland hardwoods. A notable exception is face veneer, and the manager who intends to grow much of this product will need to make special studies of financial maturity. On the other hand, special consideration probably need not be given to such products as package veneer, slack cooperage stock, cross ties, pulpwood, and fuel wood, plenty of which will inevitably be grown as a byproduct of the sawlog objective.

With standard factory lumber in view, this paper expresses tree volume in board feet by the International 1/4-inch kerf rule.[3] Tree quality is expressed in terms of log grades--for example, a two-log tree with a grade 1 butt and a grade 3 second log is classed as grade 1-3. The log grades used are those recently developed by the Forest Products Laboratory.[4] Facility in the use of these log grades is essential in making financial-maturity decisions. Special training and experience in the field are required. Familiarity with the log defects upon which the grades are based is especially important.[5]

Step 3 --Value

Tree value will here be expressed in terms of conversion surplus. Conversion surplus is described more fully elsewhere[6]. In

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3/ Mesavage, C., and Girard, J.W. Tables for estimating board-foot volume of timber. U.S. Dept. Agr., 94 pp. 1946. For sale by the Superintendent of Documents, Wash. 25, D.C.

4/ Hardwood log grades for standard lumber: proposals and results. U.S. Forest Products Laboratory D 1737, illus. 1949.

5/ Lockard, C.R., Putnam, J.A., and Carpenter, R.D. Log defects in southern hardwoods. U.S. Dept. Agr. Agr. Handbook 4, 37 pp., illus. 1950.

6/ Guttenberg, S., and Duerr, William A. A guide to profitable tree utilization. South. Forest Expt. Sta. Occas. Paper 114, 18 pp., illus. 1949.

brief, however, it is the difference between the sales value of the end product--in this case, standard factory lumber--and all the direct costs of converting the trees into this lumber--mainly labor and materials used in felling the tree and in making, transporting, and sawing the logs. Conversion surplus thus represents that part of a tree's gross product value which can be made available to increase profit or reduce loss. In the financial-maturity problem, the rate of a tree's earning is compared with the rate obtainable from alternative uses of money, with the intention of liquidating and transferring the investment in the tree if its rate of earning is below the alternative rate. The transferable investment in a tree is its conversion surplus.

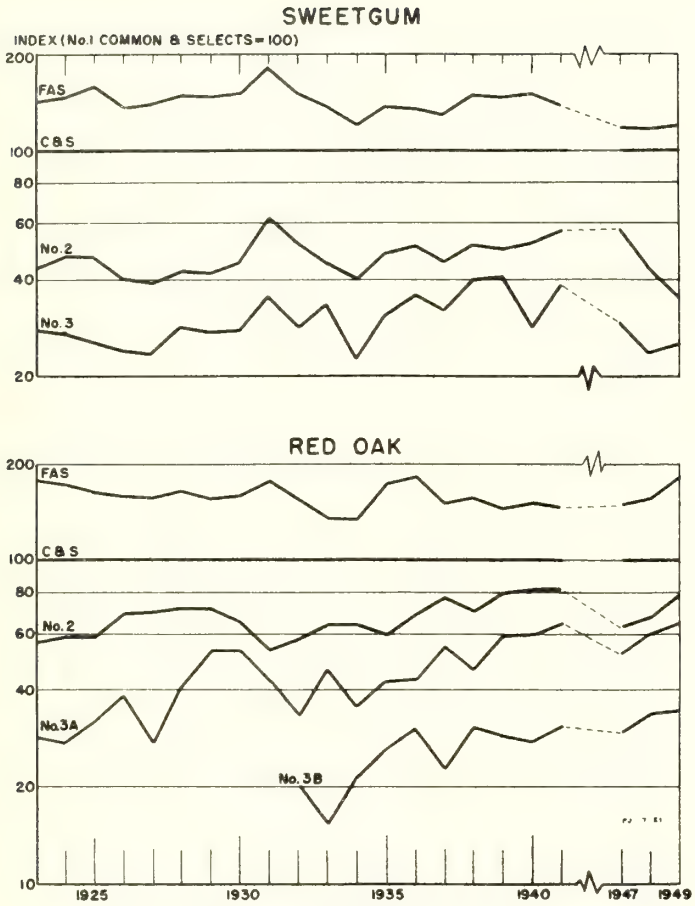
Since conversion surplus, as used here, is based upon lumber value--not log value or stumpage value--the examples to be developed will be applicable primarily to the timber owner who operates a sawmill and sells his product in the form of lumber. They will also apply to the log or stumpage seller, provided that he can count on receiving for each log or tree a price commensurate with the value of lumber it will yield. Indeed, the data on tree value presented in this paper should prove informative to buyers and sellers and thus serve to encourage log and stumpage sales at commensurate prices.

Lumber sales value

The first ingredient of conversion surplus, lumber sales value, can be estimated for any tree. Knowing the grade and volume of each log in the tree and the lumber grade yield (as given in the publication cited in footnote 4) of each grade of log, one may determine the percentage of total tree volume by lumber grade. With current sales prices for lumber, he may then calculate the weighted average price per thousand board feet of lumber represented in the tree, and from this the total value of the lumber in the tree.

The problem is how to allow for changes in the lumber market. An estimate of financial maturity involves looking ahead at least one cutting cycle--perhaps 10 years or more. We can be reasonably sure that the lumber price level will not be the same then as now. It may be higher--or perhaps lower. To help solve this problem, advantage may be taken of the fact that with all the ups and downs of the lumber market, the price of each grade tends to maintain a fairly stable relationship to that of other grades.7/ Grade prices may then be expressed as percentages (index numbers) that will have some validity over the years, and the value of lumber in a tree may be calculated in index terms instead of dollar terms, following the same procedure as would be used with dollars.

7/ Herrick, A.M. Grade yields and overrun from Indiana hardwood sawlogs. Purdue Univ. Bul. 516, 59 pp., illus. 1946.



Lumber grade index values per M board feet.

In the chart at the left, value index numbers for each grade of red oak and sweetgum lumber are plotted for the period 1923 to 1949, omitting the abnormal war years. These numbers were derived from annual average lumber grade prices. The grade prices are expressed as relatives in percent of the price of Number 1 Common and Selects. The data were obtained from Southern Hardwood Producers, Inc. of Memphis. They are representative prices, f.o.b. southern bottomland hardwood mills, for air-dried stock 4/4 inch and thicker. Because the lower grades of lumber have commanded relatively high prices in recent years as these grades have come into wider demand --a condition that is expected to continue--index numbers were determined as the average of price relatives for the years 1937 through 1941 and 1947 through 1949, with each year allowed equal weight.

The resulting indexes are as follows:

Lumber grade	Red oak	Sweetgum
Firsts and Seconds	156	134
No. 1 Common and Selects	100	100
No. 2 Common	75	49
No. 3 Common	...	32
No. 3A Common	58	...
No. 3B Common	30	...

What these numbers mean--using sweetgum as an example--is that in any marketing period, whatever price is being received for No. 1 Common and Selects, 134 percent of that price will probably prevail for First and Seconds, 49 percent for No. 2 Common, and 32 percent for No. 3 Common.

Direct costs

The other ingredient of conversion surplus, direct costs of lumber production from stump through mill, is estimated on the basis of whatever cost records are available. Direct costs include only those additional outlays that arise because the tree in question is being made into lumber. They specifically exclude all fixed or overhead costs --those costs that are unaffected by whether the particular tree is logged and milled.

For bottomland red oaks and sweetgum, available logging and milling study experience was used as a basis for estimating direct costs on a typical operation.[8] Costs were estimated in dollars per thousand board feet for trees of each species group, diameter class, and log height. Dollars were then converted to relatives in percent of the price of No. 1 Common and Selects lumber, just as was done for lumber value. This procedure is defensible on the ground that prices and direct costs (primarily wage rates) tend to fluctuate together. It makes it possible to derive conversion surplus as an index number, and thus avoid, throughout, the problem of variable dollars discussed above. The result of these calculations is given below, under step five.

Step 4 --Vigor

Tree vigor as an index of prospective diameter growth can be judged from external indicators. In bottomland hardwoods, the single most reliable indicator is the bark. Bark features stand out so strongly and are apparently so reliable that some others--site, age, root system--can largely be ignored. The crown, however, furnishes additional evidence that should be considered.

The vigor classes defined below do not apply to cull trees or poor-risk trees. They are meant to be used on trees at least 16 inches d.b.h., approximately the minimum tree size for production of standard hardwood factory lumber in the South. Three vigor classes--high, medium and low--suffice for all practical purposes and are clearly enough distinguished so that the forester or woodsman can with practice learn to recognize them and thus to estimate prospective growth with minimum use of an increment borer. Tables 1 and 2 summarize distinguishing features of the three vigor classes for bottomland red oaks and sweetgum. The growth rates associated with these classes are as follows:

Vigor class	10-year diameter growth, inches	
	Red oaks	Sweetgum
High	$3\frac{1}{2}$ - $4\frac{1}{2}$*	3 - 4
Medium	$2\frac{1}{2}$ - $3\frac{1}{2}$	2 - 3
Low	$1\frac{1}{2}$ - $2\frac{1}{2}$	1 - 2

*Exclusive of red oaks of super-vigor.

8/ The principal sources of these estimates are given on p. 18 of the publication cited in footnote 6. However, judgment was used liberally to fill in the gaps in data available for the bottomland hardwoods.

The red oaks (figs. 1 through 4) in the highest vigor class generally have smooth, thin bark with wide, open fissures vividly colored at bottom. As vigor declines, the bark thickens and roughens; fissures narrow, becoming discontinuous and obscure in low-vigor trees. Decadent red oaks, those below the class of low vigor, are usually degenerate or dying, are often stagheaded, and generally have excessive die-back of twigs. The bark (figs. 1D and 4D) looks dull or bleached, sickly, and is thick, dark, and very rough. Abundant epicormic branching is common. At the other end of the scale, a super-vigor class of red oaks may be recognized, capable of growing 5 or 6 inches in diameter in 10 years. Such trees exhibit the most favorable bark and crown characteristics to an extreme degree.

By contrast with the red oaks, sweetgum trees of highest vigor are characterized by the thickest bark, with distinct high ridges. In lower vigor classes the bark is flatter and thinner (fig. 5).

Table 1.--Bark and crown characteristics of red oaks, by vigor class

High vigor	Medium vigor	Low vigor
Bark: Healthy, fully normal in color, glossy to lustrous, fairly thin and smooth, but with shallow, wide fissures exposing fleshy, bright yellow to orange inner bark, which contrasts markedly with dark outer bark. The bark is most conclusive indicator.	Bark: Compared with high vigor, fissures less wide, inner bark duller and generally less conspicuous. Overall, bark is somewhat rougher and darker.	Bark: Dark, thick, narrowly fissured. Little or no live tissue exposed in fissures.
Crown: 3/4 or more fully formed and without close competition. Full and thrifty, with profuse long, upward-reaching young branches and twigs, light colored and lustrous. No dying leaders or dead stubs in upper part. Foliage abundant and lustrous. Crown quality and vigor more important than length or volume, except that a high ratio of crown length to stem length is a significant indicator.	Crown: 1/2 or more well formed, with abundant foliage, and without close competition. Some crowns may be entirely free of competition, but twigs will be thicker and fewer and foliage scantier than in high-vigor crowns.	Crown: Small and poorly formed, or open. Thinly foliated.

Table 2.--Bark and crown characteristics of sweetgum, by vigor class

High vigor	Medium vigor	Low vigor
Bark: Light ash-gray, corky, thick, with pronounced rounded ridges. Bottoms of fissures display streak of very light inner bark.	Bark: Gray, thick, somewhat corky (or at least with ridges slightly rounded), and free of scales or plates. Bottoms of fissures narrow, only occasionally displaying thin streak of inner bark.	Bark: Compared with medium vigor, darker, thinner, flatter. No display of inner bark. May be scaly.
Crown: 3/4 or more without close competition. Full and healthy, composed preponderantly of small ascending leaders and twigs. Foliage abundant and lustrous. Other things being equal, high ratio of crown length to stem length indicates high vigor.	Crown: 1/2 or more well formed and without close competition. Some crowns are small because of competition, but have preponderance of small twigs and abundant foliage; others are large, but heavy-limbed and with thin foliage. Foliage always of good color. Little sign of dry-topping.	Crown: Compared with medium vigor, smaller, or more preponderantly heavy-limbed and with thinner foliage. Foliage may be pale. Some trees may be stag-headed or dry-topped.

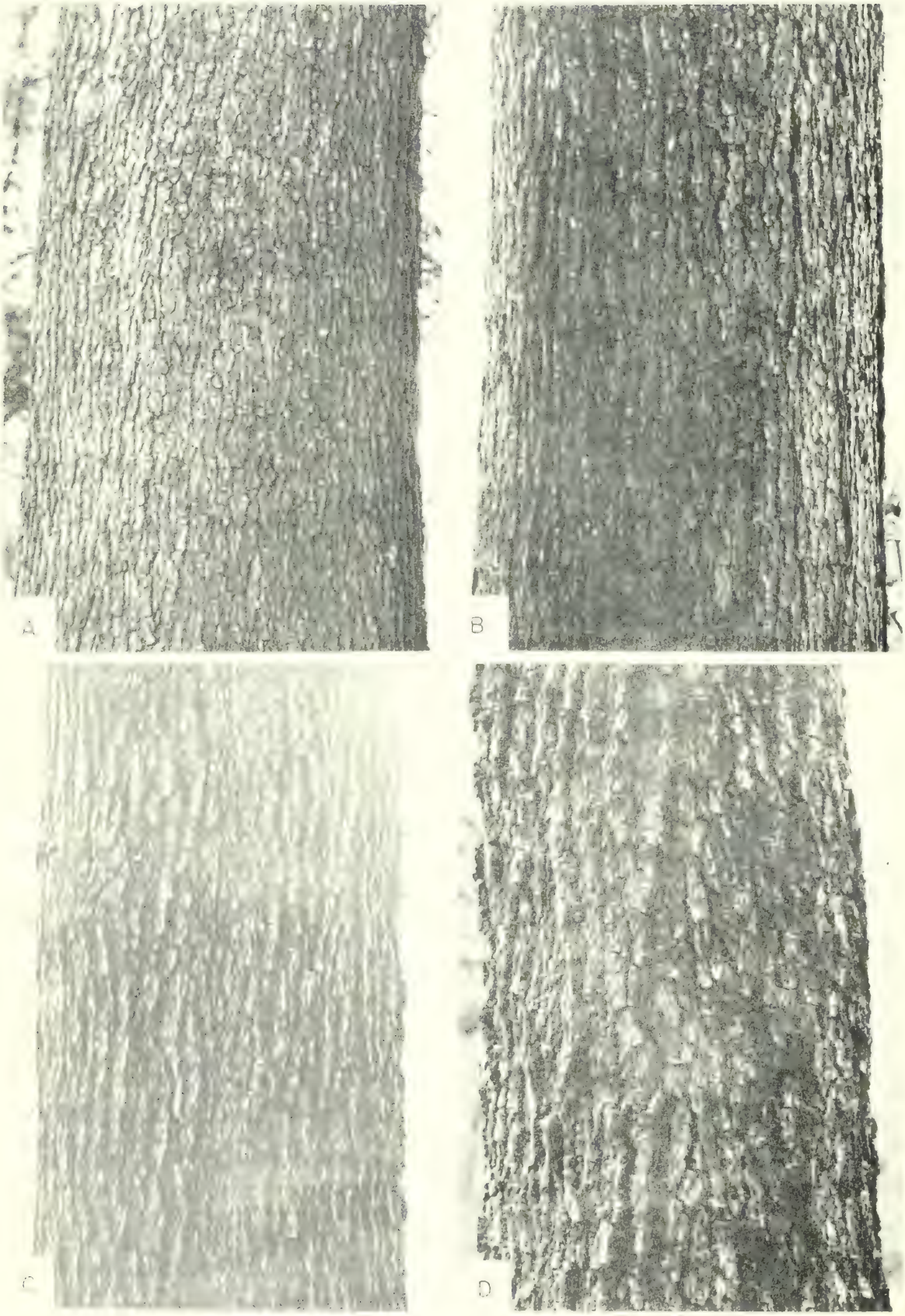


FIGURE 1.—Cherrybark Oak. *A*, High vigor. *B*, Medium vigor. *C*, Low vigor. *D*, Decadent.

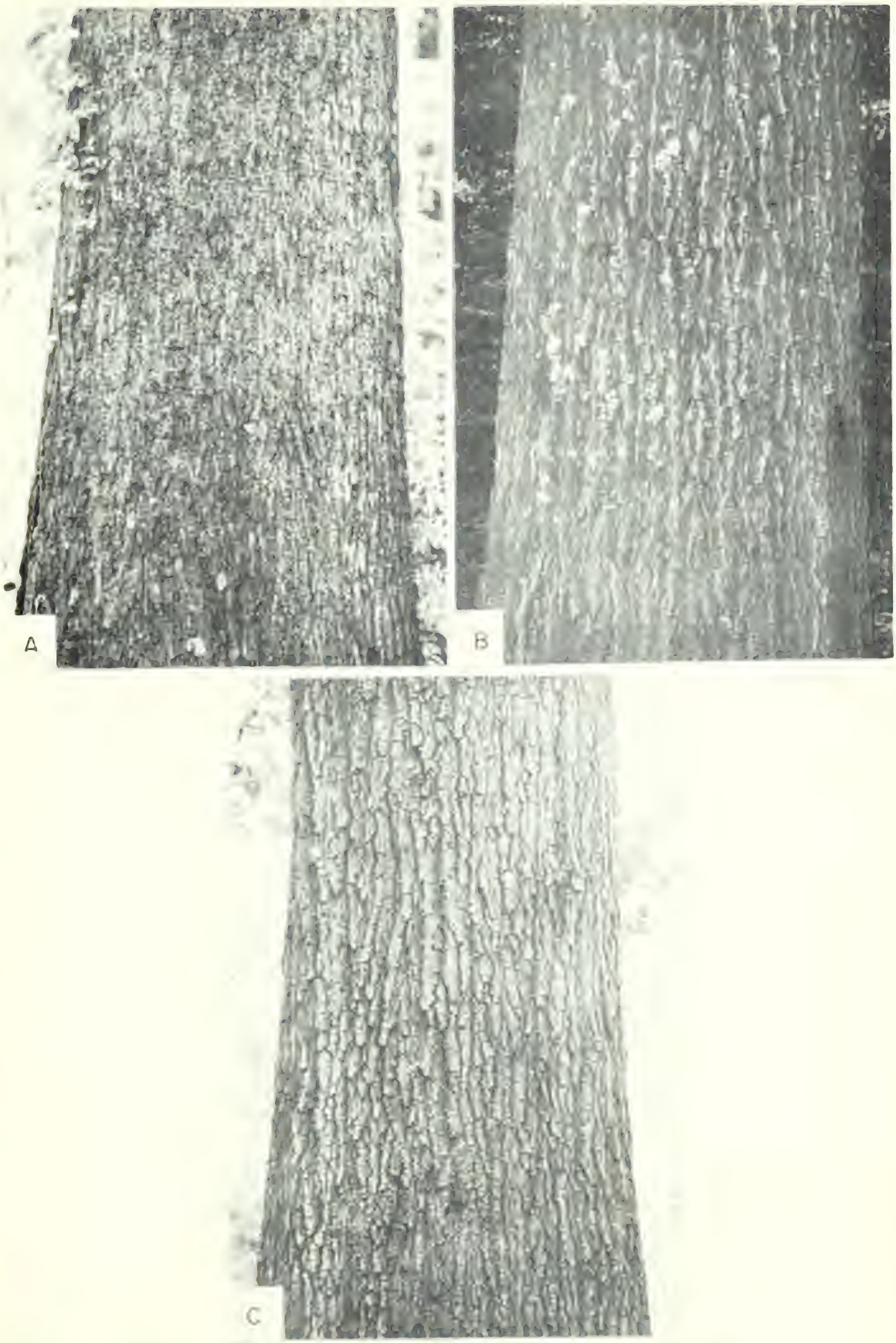


Figure 2.—Willow Oak. *A*, High vigor. *B*, Medium vigor. *C*, Low vigor.

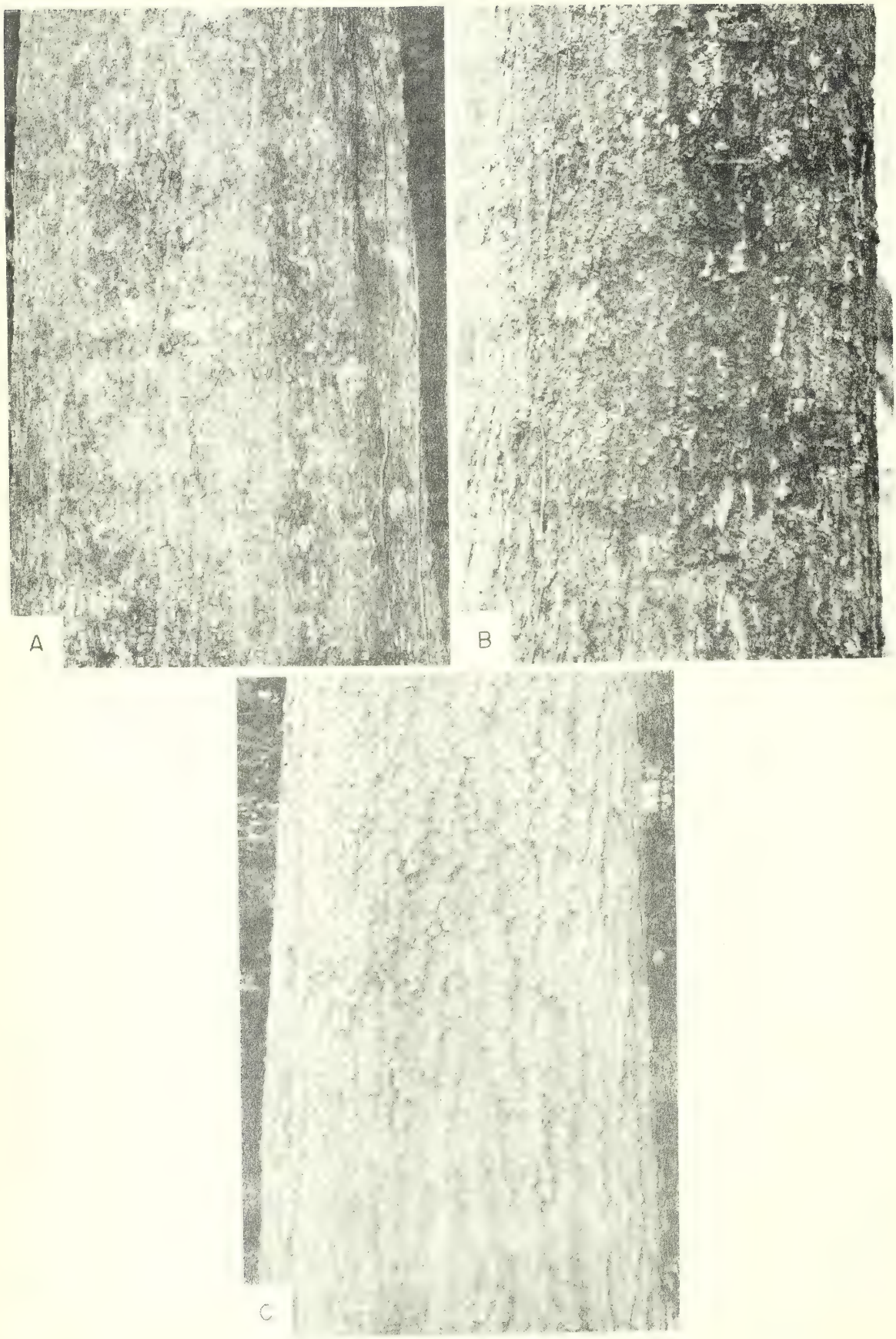


Figure 3.—Water Oak. *A*, High vigor. *B*, Medium vigor. *C*, Low vigor.

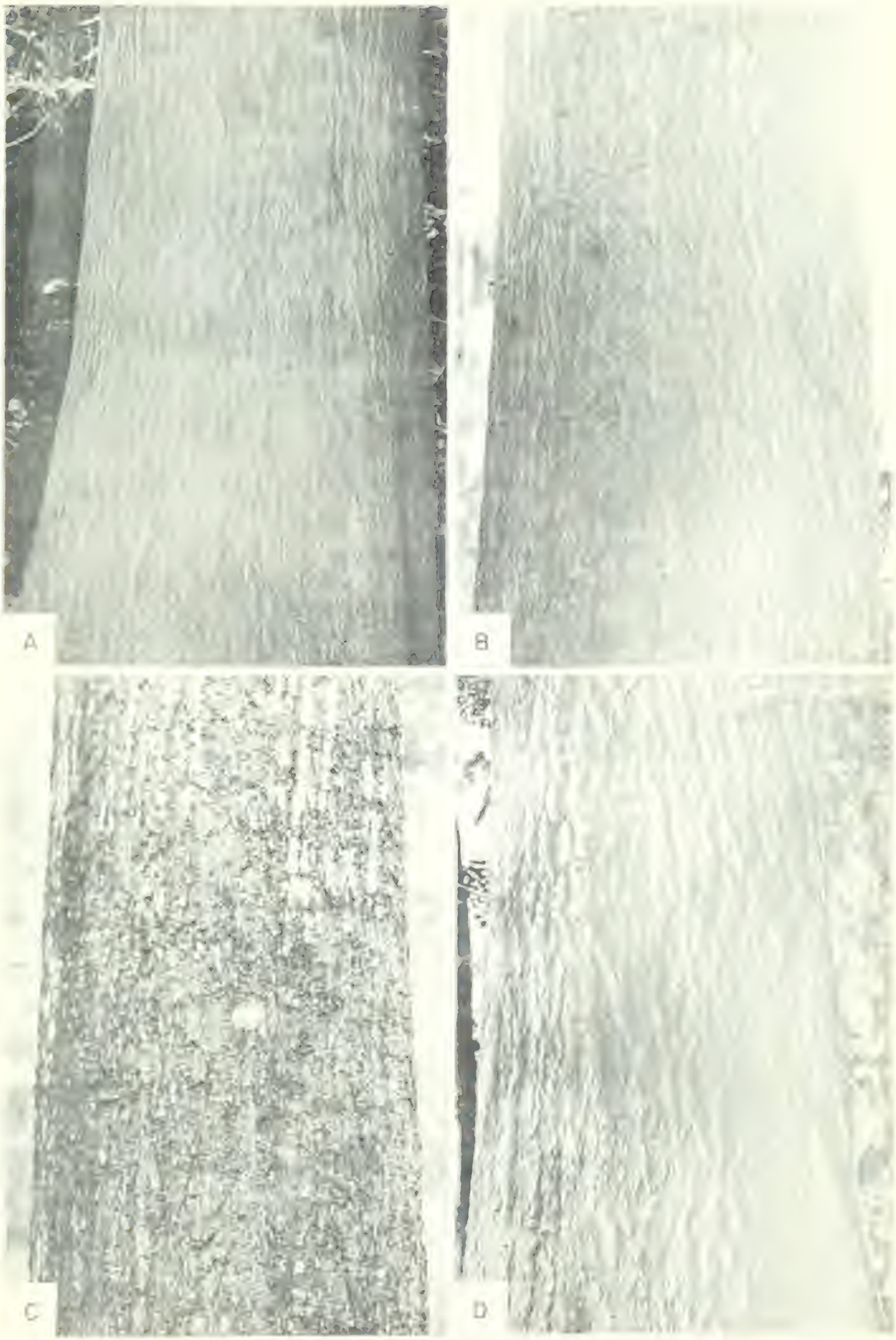


Figure 4.—Nuttall Oak. *A*, High vigor. *B*, Medium vigor. *C*, Low vigor. *D*, [illegible]

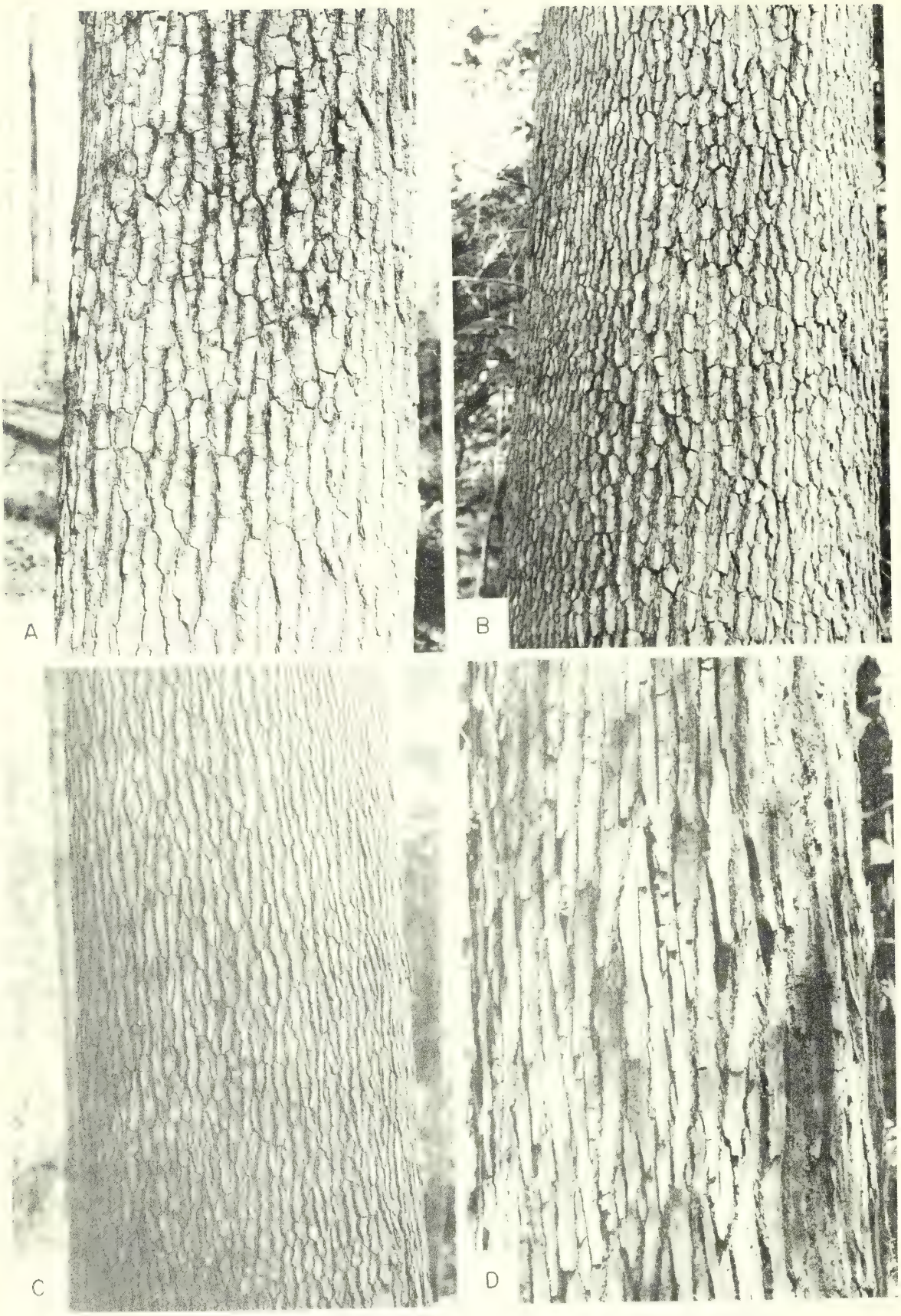


Figure 5.—Sweetgum. *A*, High vigor. *B*, Medium vigor. *C*, Low vigor. *D*, Decadent.

Step 5 --Rate of Value Increase

With vigor or growth classes defined, and with a method determined for expressing tree value according to tree size and quality, we are ready to determine rate of increase in tree value, the rate that is to be compared with the alternative rate of return to see if a tree is financially mature. The problem will be considered in two stages: first, rate of value increase when a tree changes diameter but not log height or grade; second, rate of increase when height or grade, as well as diameter, changes.

In continuing the illustration for bottomland red oaks and sweetgum, a 10-year cutting cycle is assumed. That is, it will be supposed--and this is realistic for the region--that the manager has the choice of cutting a tree now or waiting at least 10 years. Consequently our interest centers on the rate of tree-value increase in 10 years.

No change in log height or grade

Rates of value increase for bottomland red oaks and sweetgum of each vigor class are presented in tables 3 and 4. Columns 2, 3, and 4 show, in terms of index numbers as explained earlier, the lumber value, the direct costs, and the difference between these two--the conversion surplus--per thousand board feet as a weighted average for the tree. Given the number of board feet per tree as shown in column 5, the present conversion surplus per tree is read from column 6. Columns 7, 9, and 11 show the prospective conversion surplus after 10 years for each vigor class, assuming average d.b.h. growth for the class and no change in log height or grade. The ratio of value after 10 years to value now determines for each vigor class (columns 8, 10, and 12) the compound rate of annual increase.

Take the problem of a forest manager who is deciding whether to mark a two log 28-inch Nuttall oak, grade 1-2, high vigor--or whether to let it grow for another 10 years. Large limbs above the second log permanently limit the merchantable height, nor is the grade of either log likely soon to improve. The alternative rate of return which the manager follows as his guide is 5 percent. Table 3 indicates that this Nuttall oak will earn less than this rate--only 4.4 percent--in the coming decade. It is therefore financially mature and should be marked for cutting.

Changes in height and grade

Both log height and grade normally change as a tree grows in diameter. Small limbs die and fall off, and clear wood covers the knots.

Table 3.--Rate of value increase of red oaks by log height, grade, diameter, and vigor class

Diam. breast high (inches) (1)	Per M board feet: Gross lumber value (2)	Direct costs (3)	Conversion surplus (4)	Lumber per tree (5)	Conversion surplus per tree by vigor class: Now (6)	High vigor: After 10 yrs. (7)	Annual increase (8)	Medium vigor: After 10 yrs. (9)	Annual increase (10)	Low vigor: After 10 yrs. (11)	Annual increase (12)
	- - - Index - - -			Bd.ft.	- - Index - -		Percent	Index	Percent	Index	Percent
				1-LOG-TREES, GRADE 1							
18	85.5	61.8	23.7	112	2.65	6.37	9.1	5.30	7.2	4.36	5.1
20	87.9	57.0	30.9	141	4.36	8.59	7.0	7.40	5.4	6.37	3.9
22	90.2	53.6	36.6	174	6.37	11.26	5.9	9.88	4.5	8.59	3.0
24	92.1	51.0	41.1	209	8.59	14.28	5.2	12.70	4.0	11.26	2.7
26	94.6	49.0	45.6	247	11.26	17.70	4.6	15.94	3.5	14.28	2.4
28	96.8	47.4	49.4	289	14.28	21.35	4.1	19.49	3.2	17.70	2.1
30	99.2	46.2	53.0	334	17.70	25.63	3.8	23.43	2.8	21.35	1.9
32	101.3	45.4	55.9	382	21.35	30.06	3.5	27.89	2.7	25.63	1.8
34	104.0	44.8	59.2	433	25.63	34.21	2.9	32.14	2.3	30.06	1.6
36	106.2	44.6	61.6	488	30.06	38.45	2.5	36.23	1.9	34.21	1.3
				GRADE 2							
16	70.0	68.0	2.0	87	.17	2.27	29.5	1.64	25.4	1.08	20.3
18	71.4	61.8	9.6	112	1.08	3.72	13.2	2.95	10.6	2.27	7.7
20	73.1	57.0	16.1	141	2.27	5.37	9.0	4.53	7.2	3.72	5.1
22	75.0	53.6	21.4	174	3.72	7.31	7.0	6.32	5.4	5.37	3.7
24	76.7	51.0	25.7	209	5.37	9.57	5.9	8.40	4.6	7.31	3.1
26	78.6	49.0	29.6	247	7.31	12.16	5.2	10.84	4.0	9.57	2.7
28	80.5	47.4	33.1	289	9.57	14.97	4.6	13.52	3.5	12.16	2.4
30	82.6	46.2	36.4	334	12.16	17.68	3.8	16.31	3.0	14.97	2.1
32	84.6	45.4	39.2	382	14.97	20.49	3.2	19.06	2.4	17.68	1.7
				GRADE 3							
18	63.8	61.8	2.0	112	.22	2.09	25.2	1.57	21.7	1.10	17.5
20	64.8	57.0	7.8	141	1.10	3.26	11.5	2.62	9.1	2.09	6.6
22	65.6	53.6	12.0	174	2.09	4.57	8.1	3.91	6.5	3.26	4.5
24	66.6	51.0	15.6	209	3.26	6.13	6.5	5.33	5.0	4.57	3.4
26	67.5	49.0	18.5	247	4.57	7.85	5.6	7.00	4.4	6.13	3.0
28	68.6	47.4	21.2	289	6.13	9.52	4.5	8.69	3.6	7.85	2.5
30	69.7	46.2	23.5	334	7.85	11.35	3.8	10.40	2.8	9.52	2.0
				2-LOG-TREES, GRADE 1-2							
18	80.7	61.2	19.5	182	3.55	9.56	10.4	6.87	6.8	6.32	6.0
20	82.7	55.8	26.9	235	6.32	13.35	7.8	11.38	6.1	9.56	4.2
22	84.7	52.2	32.5	294	9.56	17.80	6.4	15.46	4.9	13.35	3.4
24	86.9	49.6	37.3	358	13.35	22.96	5.6	20.23	4.2	17.80	2.9
26	89.0	47.5	41.5	429	17.80	28.89	5.0	25.85	3.8	22.96	2.6
28	91.2	46.0	45.2	508	22.96	35.24	4.4	32.04	3.4	28.89	2.3
30	93.5	44.7	48.8	592	28.89	42.28	3.9	38.60	2.9	35.24	2.0
32	95.5	43.9	51.6	683	35.24	49.95	3.5	46.08	2.7	42.28	1.8
34	97.6	43.4	54.2	780	42.28	57.79	3.2	53.85	2.4	49.95	1.7
36	99.8	43.3	56.5	884	49.95	65.87	2.8	61.80	2.2	57.79	1.5

Table 3.--(Continued)

Diam. breast high (inches) (1)	Per M board feet: Gross lumber value (2)	Direct costs (3)	Conversion surplus (4)	Lumber per tree (5)	Conversion surplus per tree by vigor class: Now (6)	High vigor: After 10 yrs. (7)	Annual increase (8)	Medium vigor: After 10 yrs. (9)	Annual increase (10)	Low vigor: After 10 yrs. (11)	Annual increase (12)
	- - - Index - - -			Bd.ft.	- - Index - -		Percent	Index	Percent	Index	Percent
					GRADE 1-3						
18	74.3	61.2	13.1	182	2.38	7.70	12.5	6.15	10.0	4.84	7.3
20	76.4	55.8	20.6	235	4.84	11.03	8.3	9.25	6.7	7.70	4.8
22	78.4	52.2	26.2	294	7.70	14.97	6.9	12.94	5.3	11.03	3.7
24	80.4	49.6	30.8	358	11.03	19.61	5.9	17.15	4.5	14.97	3.1
26	82.4	47.5	34.9	429	14.97	24.75	5.1	22.12	4.0	19.61	2.7
28	84.6	46.0	38.6	508	19.61	31.01	4.7	27.70	3.5	24.75	2.4
30	86.5	44.7	41.8	592	24.75	36.00	3.8	33.42	3.0	31.01	2.3
32	88.7	43.3	45.4	683	31.01	41.90	3.2	38.87	2.3	36.00	1.5
					GRADE 2-3						
18	67.6	61.2	6.4	182	1.16	5.23	16.2	4.09	13.4	3.08	10.3
20	68.9	55.8	13.1	235	3.08	7.73	9.7	6.43	7.6	5.23	5.5
22	70.0	52.2	17.8	294	5.23	10.68	7.4	9.16	6.4	7.73	4.0
24	71.2	49.6	21.6	358	7.73	14.02	6.1	12.28	4.7	10.68	3.3
26	72.4	47.5	24.9	429	10.68	17.94	5.3	15.94	4.1	14.02	2.8
28	73.6	46.0	27.6	508	14.02	22.47	4.8	20.07	3.7	17.94	2.5
30	75.0	44.7	30.3	592	17.94	26.96	4.2	24.60	3.2	22.47	2.3
32	76.2	43.3	32.9	683	22.47	31.86	3.6	29.40	2.7	26.96	1.8
					GRADE 3-3						
18	62.2	61.2	1.0	182	.18	3.12	32.8	2.33	29.2	1.55	23.9
20	62.4	55.8	6.6	235	1.55	4.83	12.0	3.96	9.8	3.12	7.3
22	62.8	52.2	10.6	294	3.12	6.82	8.1	5.78	6.4	4.83	4.4
24	63.1	49.6	13.5	358	4.83	8.94	6.4	7.78	4.9	6.82	3.5
26	63.4	47.5	15.9	429	6.82	11.48	5.3	10.06	4.0	8.94	2.7
28	63.6	46.0	17.6	508	8.94	13.90	4.5	12.56	3.5	11.48	2.5
30	64.1	44.7	19.4	592	11.48	16.68	3.8	15.28	2.9	13.90	1.9
					3-LOG-TREES, GRADE 1-1-3						
26	87.1	46.3	40.8	594	24.24	38.30	4.7	34.51	3.6	30.91	2.5
28	89.0	44.9	44.1	701	30.91	46.82	4.2	42.49	3.2	38.30	2.2
30	91.0	44.0	47.0	815	38.30	56.06	3.9	51.63	3.0	46.82	2.0
32	93.1	43.4	49.7	942	46.82	66.30	3.5	61.27	2.7	56.06	1.8
34	95.2	43.1	52.1	1076	56.06	77.08	3.2	71.71	2.5	66.30	1.7
36	97.3	43.0	54.3	1221	66.30	88.10	2.8	82.59	2.2	77.08	1.5
					GRADE 1-2-3						
26	80.1	46.3	33.8	594	20.08	32.93	5.1	29.55	3.9	26.36	2.8
28	82.5	44.9	37.6	701	26.36	40.51	4.4	36.54	3.3	32.93	2.3
30	84.4	44.0	40.4	815	32.93	48.85	4.0	44.45	3.0	40.51	2.1
32	86.4	43.4	43.0	942	40.51	58.10	3.7	53.09	2.7	48.85	1.9
34	88.5	43.1	45.4	1076	48.85	67.45	3.3	62.53	2.5	58.10	1.7
36	90.7	43.0	47.7	1221	58.24	77.78	2.9	72.61	2.2	67.45	1.5

Table 4.--Rate of value increase of sweetgum, by log height, grade, diameter, and vigor class

Diam. breast high (inches) (1)	Per M board feet: Gross lumber value (2)	Per M board feet: Direct costs (3)	Per M board feet: Conversion surplus (4)	Lumber per tree (5)	Conversion surplus per tree by vigor class: Now (6)	High vigor: After 10 yrs. (7)	High vigor: Annual increase (8)	Medium vigor: After 10 yrs. (9)	Medium vigor: Annual increase (10)	Low vigor: After 10 yrs. (11)	Low vigor: Annual increase (12)
	- - - Index - - - -			Bd.ft.	- Index - -		Percent	Index	Percent	Index	Percent
				1-LOG-TREES, GRADE 1							
18	89.3	61.6	27.7	122	3.38	6.58	6.9	5.59	5.2	4.64	3.2
20	90.7	57.4	33.3	154	5.13	8.80	5.5	7.63	4.0	6.58	2.5
22	92.1	54.4	37.7	190	7.16	11.40	4.8	10.04	3.4	8.80	2.1
24	93.6	52.0	41.6	226	9.40	14.35	4.3	12.84	3.2	11.40	1.9
26	95.1	50.1	45.0	269	12.10	17.55	3.8	15.95	2.8	14.35	1.7
28	96.7	48.7	48.0	312	14.98	21.12	3.5	19.29	2.6	17.55	1.6
30	98.4	47.6	50.8	363	18.44	25.15	3.2	23.00	2.2	21.12	1.4
32	100.2	46.9	53.3	416	22.17	29.47	2.9	27.15	2.1	25.15	1.3
34	102.1	46.5	55.6	469	26.08	34.10	2.7	31.80	2.0	29.47	1.2
36	104.3	46.5	57.8	530	30.63	38.52	2.3	36.30	1.7	34.10	1.1
				GRADE 2							
18	68.9	61.6	7.3	122	.89	3.28	13.9	2.50	10.9	1.83	7.5
20	71.2	57.4	13.8	154	2.13	4.91	8.7	4.04	6.6	3.28	4.4
22	73.6	54.4	19.2	190	3.65	6.94	6.6	5.89	4.9	4.91	3.0
24	76.0	52.0	24.0	226	5.42	9.38	5.6	8.11	4.1	6.94	2.5
26	78.5	50.1	28.4	269	7.64	12.24	4.8	10.80	3.5	9.38	2.1
28	80.9	48.7	32.2	312	10.05	15.43	4.4	13.79	3.2	12.24	2.0
30	83.6	47.6	36.0	363	13.07	18.84	3.7	17.07	2.7	15.43	1.7
32	86.0	46.9	39.1	416	16.27	22.67	3.4	20.69	2.4	18.84	1.5
34	88.6	46.5	42.1	469	19.74	26.98	3.2	24.83	2.3	22.67	1.4
36	91.2	46.5	44.7	530	23.69	31.40	2.8	29.14	2.1	26.98	1.3
				GRADE 3							
22	56.9	54.4	2.5	190	.47	2.33	17.3	1.72	13.8	1.18	9.6
24	58.4	52.0	6.4	226	1.45	3.70	9.8	3.00	7.5	2.33	4.9
26	60.0	50.1	9.9	269	2.66	5.40	7.3	4.52	5.4	3.70	3.4
28	61.8	48.7	13.1	312	4.09	7.34	6.0	6.32	4.4	5.40	2.8
30	63.7	47.6	16.1	363	5.84	9.44	4.9	8.38	3.7	7.34	2.3
				2-LOG-TREES, GRADE 1-2							
18	79.8	61.4	18.4	209	3.85	9.10	9.0	7.40	6.7	5.90	4.4
20	81.5	56.8	24.7	268	6.62	12.73	6.8	10.88	5.1	9.10	3.2
22	83.2	53.5	29.7	336	9.98	16.99	5.5	14.78	4.0	12.73	2.5
24	85.0	51.1	33.9	404	13.70	21.85	4.8	19.42	3.6	16.99	2.2
26	86.7	49.2	37.5	485	18.19	27.42	4.2	24.52	3.3	21.85	1.9
28	88.5	47.8	40.7	568	23.12	34.02	3.9	30.56	2.8	27.42	1.7
30	90.4	46.8	43.6	664	28.95	40.75	3.5	37.18	2.5	34.02	1.6
32	92.5	46.0	46.5	765	35.57	48.20	3.1	44.42	2.2	40.75	1.4
34	94.6	45.6	49.0	868	42.53	56.47	2.9	52.32	2.1	48.25	1.3
36	96.9	45.6	51.3	984	50.48	65.05	2.6	60.90	1.9	56.47	1.1
				GRADE 1-3							
18	74.1	61.4	12.7	209	2.65	7.15	10.4	5.73	8.0	4.42	5.2
20	75.7	56.8	18.9	268	5.07	10.33	7.4	8.70	5.5	7.15	3.5
22	77.1	53.5	23.6	336	7.93	13.83	5.7	12.00	4.2	10.33	2.7
24	78.7	51.1	27.6	404	11.15	18.14	5.0	15.92	3.6	13.80	2.2
26	79.8	49.2	30.6	485	14.84	23.08	4.5	20.52	3.3	18.14	2.0
28	81.8	47.8	34.0	568	19.31	28.75	4.1	25.84	3.0	23.08	1.8
30	83.6	46.8	36.8	664	24.44	34.40	3.5	31.63	2.6	28.75	1.6
32	85.5	46.0	39.5	765	30.22	40.20	2.9	37.10	2.1	34.40	1.3
				GRADE 2-3							
18	61.9	61.4	.5	209	.10	3.59	42.9	2.43	37.4	1.43	30.9
20	64.0	56.8	7.2	268	1.93	6.19	12.9	4.87	9.7	3.59	6.4
22	66.1	53.5	12.6	336	4.23	9.33	8.2	7.68	6.1	6.19	3.9
24	68.2	51.1	17.1	404	6.91	13.14	6.6	11.18	4.9	9.33	3.0
26	70.3	49.2	21.1	485	10.23	17.55	5.6	15.28	4.1	13.14	2.5
28	72.7	47.8	24.9	568	14.14	22.71	4.8	20.05	3.6	17.55	2.2
30	75.1	46.8	28.3	664	18.79	28.32	4.2	25.39	3.1	22.71	1.9
32	77.4	46.0	31.4	765	24.02	34.60	3.7	31.44	2.7	28.32	1.7

Table 4.--(Continued)

Diam. breast high (inches) (1)	Per M board feet: Gross lumber value (2)	Per M board feet: Direct costs (3)	Per M board feet: Conversion surplus (4)	Lumber per tree (5)	Conversion surplus per tree by vigor class: Now (6)	High vigor: After 10 yrs. (7)	High vigor: Annual increase (8)	Medium vigor: After 10 yrs. (9)	Medium vigor: Annual increase (10)	Low vigor: After 10 yrs. (11)	Low vigor: Annual increase (12)
	- - - Index - - -			Bd.ft.	- - Index - -		Percent	Index	Percent	Index	Percent
					GRADE 3-3						
20	57.2	56.8	.4	268	.11	3.89	42.6	2.72	37.6	1.61	30.8
22	59.8	53.5	6.3	336	2.12	6.53	11.6	5.16	9.3	3.89	6.3
24	62.2	51.1	11.1	404	4.48	9.38	7.7	7.96	5.9	6.53	3.8
26	64.1	49.2	14.9	485	7.23	12.27	5.4	10.52	4.1	9.38	2.6
28	65.6	47.8	17.8	568	10.11	15.29	4.2	13.72	3.1	12.27	2.0
30	66.5	46.8	19.7	664	13.08	18.42	3.5	16.84	2.6	15.29	1.6
32	67.0	46.0	21.0	765	16.06	21.85	3.1	20.10	2.3	18.42	1.4
					3-LOG-TREES, GRADE 1-1-2						
24	87.9	51.4	36.5	540	19.71	30.86	4.6	27.45	3.4	24.24	2.1
26	89.0	49.4	39.6	654	25.90	38.39	4.0	34.50	2.9	30.86	1.8
28	90.2	47.9	42.3	772	32.66	46.85	3.7	42.54	2.7	38.39	1.6
30	91.3	46.8	44.5	908	40.41	55.70	3.3	51.17	2.4	46.85	1.5
32	92.5	45.9	46.6	1054	49.12	65.43	2.9	60.50	2.1	55.70	1.3
34	93.8	45.4	48.4	1202	58.18	75.58	2.6	70.50	1.9	65.43	1.2
36	95.0	45.3	49.7	1369	68.04	85.75	2.3	80.73	1.7	75.58	1.0
					GRADE 1-1-3						
24	83.5	51.4	32.1	540	17.33	27.55	4.7	24.45	3.5	21.63	2.2
26	84.6	49.4	35.2	654	23.02	34.45	4.1	30.87	3.0	27.55	1.8
28	85.7	47.9	37.8	772	29.18	42.30	3.8	38.25	2.7	34.45	1.6
30	86.8	46.8	40.0	908	36.32	50.43	3.3	46.32	2.5	42.30	1.5
32	88.0	45.9	42.1	1054	44.37	59.24	2.9	54.70	2.1	50.43	1.3
34	89.1	45.4	43.7	1202	52.53	68.65	2.7	64.02	2.0	59.24	1.2
36	90.3	45.3	45.0	1369	61.60	77.75	2.4	73.31	1.8	68.65	1.1
					GRADE 1-2-2						
20	79.0	57.5	21.5	349	7.50	14.85	7.1	12.55	5.3	10.22	3.1
22	80.1	54.0	26.1	443	11.56	19.97	5.6	17.28	4.1	14.85	2.5
24	81.1	51.4	29.7	540	16.04	25.79	4.9	22.80	3.6	19.97	2.2
26	82.2	49.4	32.8	654	21.45	32.38	4.2	28.98	3.1	25.79	1.9
28	83.3	47.9	35.4	772	27.33	39.84	3.8	36.00	2.8	32.38	1.7
30	84.5	46.8	37.7	908	34.23	47.62	3.4	43.61	2.5	39.84	1.5
32	85.6	45.9	39.7	1054	41.84	56.11	3.0	51.86	2.2	47.62	1.3
34	86.8	45.4	41.4	1202	49.76	65.03	2.7	60.60	2.0	56.11	1.2
36	88.0	45.3	42.7	1369	58.46	73.75	2.4	69.38	1.7	65.03	1.1
					GRADE 1-2-3						
18	74.0	62.3	11.7	267	3.12	8.78	10.9	6.97	8.4	5.30	5.4
20	75.0	57.5	17.5	349	6.11	12.82	7.7	10.73	5.8	8.78	3.7
22	76.1	54.0	22.1	443	9.79	17.55	6.0	15.05	4.4	12.82	2.7
24	77.1	51.4	25.7	540	13.88	22.88	5.1	20.13	3.8	17.55	2.4
26	78.2	49.4	28.8	654	18.84	28.95	4.4	25.82	3.2	22.88	2.0
28	79.3	47.9	31.4	772	24.24	35.84	4.0	32.25	2.9	28.95	1.8
30	80.5	46.8	33.7	908	30.60	43.08	3.5	39.39	2.6	35.84	1.6
32	81.6	45.9	35.7	1054	37.62	51.10	3.1	46.95	2.2	43.08	1.4
34	82.8	45.4	37.4	1202	44.95	59.85	2.9	55.42	2.1	51.10	1.3
36	84.2	45.3	38.9	1369	53.25	68.92	2.6	64.35	1.9	59.85	1.2
					GRADE 1-3-3						
18	69.9	62.3	7.6	267	2.03	7.10	13.3	5.45	10.4	3.95	6.9
20	71.0	57.5	13.5	349	4.71	10.75	8.6	8.85	6.5	7.10	4.2
22	72.1	54.0	18.1	443	8.02	15.00	6.5	12.45	4.5	10.75	3.0
24	73.2	51.4	21.8	540	11.77	19.83	5.4	17.32	3.9	15.00	2.4
26	74.2	49.4	24.8	654	16.22	25.38	4.6	22.50	3.3	19.83	2.0
28	75.3	47.9	27.4	772	21.15	31.64	4.1	28.47	3.0	25.38	1.8
30	76.4	46.8	29.6	908	26.88	38.30	3.6	34.95	2.7	31.64	1.6
32	77.6	45.9	31.7	1054	33.41	45.67	3.2	41.96	2.3	38.30	1.4
34	78.8	45.4	33.4	1202	40.15	53.60	2.9	49.58	2.1	45.67	1.3
36	80.1	45.3	34.8	1369	47.64	61.83	2.6	57.68	1.9	53.60	1.2

Butt logs of small trees are subject to radical improvement in grade once the limbs are dropped, because of the increasing thickness of clear wood deposited over the heart center. The same thing happens, though to a lesser degree, to upper logs. Furthermore, logs may improve in grade merely with increase in diameter. In the upper bole, additional logs are created as girth is added to meet minimum specifications and as the bole is cleared so as to meet quality specifications. Thus small, short hardwoods of low grade are often capable of developing into 2- or 3-log, high-grade trees. Generally, most of the potential improvement in grade is realized by the time a hardwood tree reaches 24 or 26 inches d.b.h., though exceptions may be found in the improvement in quality of low-grade upper logs. Most large hardwoods are likely to have their log height firmly established by the position and form of the crown.

Potential changes in log height and grade can, with experience, be recognized by the forester or woodsman. To recognize them is essential in determining financial maturity.

Tables 3 and 4 may be used as a basis for calculating (though not for reading directly) the rate of value increase for trees expected to grow in log height or improve in grade. Suppose that the two-log, 28-inch, grade 1-2 Nuttall oak is expected to add a third log in the coming decade, so as to become a 32-inch, grade 1-2-3 tree. Table 3 shows that the value now is index 22.96, and that the value in 10 years (reading in the same column, opposite the expected grade and diameter) will be index 40.51. A calculation of the ratio of these indexes and reference to compound-interest tables discloses that the expected rate of increase is 5.8 percent. With a 5-percent alternative rate, this tree is not yet mature.

In the same way, it is possible to evaluate prospective increases in grade, or in both height and grade. If the grade 1-2 Nuttall oak grows to grade 1-1-3 in 10 years, the rate of value increase will be even higher, 7.4 percent.

As managed trees grow from 18 to 36 inches in d.b.h., they may be expected to improve in quality and log height about in the stages shown in column 2 of table 5. That is, a high vigor 18-inch tree with one grade 2 log will grow into a 22-inch grade 2-3 tree in 10 years. In doing so it will earn 17.1 percent annually (col. 3), substantially more than the 13.2 percent (col. 4) it would have made without these changes. A comparison of columns 3 and 4 of table 5 will demonstrate the marked effect that changes in log grade and height have upon a tree's earning power. It is clear that any tree that is placed by table 3 or 4 near the borderline of financial maturity should be left for additional growth if it promises to extend its log height or improve its grade.

Step 6 --Effect of Other Trees

In judging financial maturity, one cannot, of course, consider a tree solely on its own merits. Every forest tree is in more or less competition with other trees, and this competition affects the desirability of the tree as an investment. Some trees which, judged alone, are apparently financially mature turn out not to be mature when one or more other trees are brought into consideration. Likewise, trees may prove to be mature which, considered by themselves, were not so. The principle covering the effect of other trees upon financial maturity is this: the aim of the manager should be to maintain on each acre that volume of timber which, within the requirements of the silvicultural system and the program of regulation, has the greatest possible conversion surplus in trees not yet financially mature. For reasons made clear in the reference cited in footnote 2, this principle will result in securing the highest income from each acre that the alternative rate of return will afford.

Therefore, where two competing trees are both mature, but where removal of one would raise the vigor of the other sufficiently to make it no longer mature, a general rule is to retain that tree for growth which has the higher value, now or prospectively--the greater size or higher grade, or the better chance of increasing its size or improving its grade. The other tree should be cut.

Take the case of two competing red oaks. Both are of medium vigor, but if either is cut, the vigor of the other will become high. Following are the pertinent data on these oaks, read from table 3:

Table 5.--Rate of value increase for managed trees of high vigor, with and without log height and grade changes

Tree d.b.h. (inches) (1)	Tree grade (2)	Annual conversion-surplus increase: With height and grade changes (3)	Annual conversion-surplus increase: Without height and grade changes (4)
		- - - Percent - - -	
		RED OAKS	
18	2	17.1	13.2
20	2-3	13.6	9.7
22	2-3	13.0	7.4
24	1-3	7.6	5.9
26	1-2	6.3	5.0
28	1-2	5.8	4.4
30	1-2-3	5.5	4.0
32	1-2-3	5.0	3.7
34	1-1-3	...	3.2
36	1-1-3	...	2.8
		SWEETGUM	
18	2-3	53.0	42.9
20	1-3	9.7	7.4
22	1-3-3	8.1	6.5
24	1-2-3	6.4	5.1
26	1-2-3	5.6	4.4
28	1-2-2	5.5	3.8
30	1-2-2	5.0	3.4
32	1-1-2	...	2.9
34	1-1-2	...	2.6

	Tree A	Tree B
D.b.h., inches	26	28
Two-log trees, grade	1-2	2-3
Conversion surplus	17.80	14.02
Medium vigor:		
Conversion surplus after 10 years	25.85	20.07
Rate of increase, percent	3.8	3.7
High vigor:		
Conversion surplus after 10 years	28.89	22.47
Rate of increase, percent	5.0	4.8

With a 4-percent alternative rate of return, one of the trees is mature and should be cut, while the other should be left to grow one more cycle. Since Tree A, the 26-inch grade 1-2 oak, has the higher value both now and prospectively, it should be left to grow.

A comparison of these alternative trees will show the reasoning behind the rule. For convenience, assume that conversion surplus equals dollars. Then if B is cut, its $14.02 will earn $6.73 in ten years at 4 percent compound interest. Tree A will earn $11.09 ($28.89-17.80). The total earnings of both trees will thus be $17.82. Suppose A is cut; its $17.80 will earn $8.54 at 4 percent while tree B earns $8.45 ($22.47 -14.02); the total earnings of both trees will be $16.99. This earning is 83 cents less than is derived from the alternative of cutting B; therefore, tree A should be left to grow, and tree B marked for cutting. The rule is designed to cover the vast majority of the numerous alternatives facing the forest manager. There will be exceptions, but the virtue of the rule is that it obviates making separate calculations for every alternative that arises.

Other considerations relating to the stand may affect the financial-maturity decision. A tree may be otherwise mature and still not ready for harvest if it is needed as a seed source. Again, the need for holding the cut within a cutting budget, or of building the growing stock towards optimum diameter-class distributions, may result in leaving for another cutting cycle some trees that apparently are financially mature. In some areas there may be insufficient timber volume to support a commercial cutting operation despite a sprinkling of "mature" trees. On the other hand, the owner may be forced to cut some trees in order to obtain a regular income or a regular supply of logs for a sawmill; these are cases where the alternative rate of return has risen, at least temporarily.

A related problem is the case of trees smaller than sawlog size. For such timber, financial-maturity decisions are rather easily reached. Trees between 8 and 14 inches in diameter usually have boles sufficiently well defined so that development in sawlog length and quality can be predicted with fair accuracy. All low-grade trees interfering with the

growth of better stems should be eliminated--and utilized if possible. In general, low-grade trees, especially those that promise to develop no better than a grade-3 butt log, should not be permitted to grow in competition with better trees. Comparing the prospective earnings of such trees with the earnings that may be obtained from higher grade trees will generally show that the low-grade trees reach financial maturity while still below sawlog size. For the poorest specimens, outright deadening may often be justified.

Two other points have yet to be considered. The first of these is that the percentage rates of increase and index values are not directly comparable for competing trees of different species groups. Each group has its own index base, and only if No. 1 Common and Selects red oak sold consistently for the same price as that of sweetgum would the two species be comparable. Although differences in the base value do exist, they are not great. Sometimes oak sells at the higher price and at other times sweetgum does. On the average for the base period, sweetgum was somewhat more valuable than red oak, but by less than 10 percent. Consequently, no great harm will result if direct comparisons are made, provided that where the decision is close a sweetgum is favored over a red oak.

The other point relates to the super-vigorous red oaks capable of growing on the average 6 inches in 10 years. For such trees financial maturity arrives at a higher diameter than for high-vigor trees. Table 3 shows that an ordinary high-vigor 3-log 28-inch red oak, grade 1-2-3, will earn 4.4 percent compound over the next ten years. At a 5 percent alternative rate of return, the tree is financially mature. However, if the same tree were of super-vigor, it would increase in value from 40.51 to 67.45 (at 34 inches) and the rate of earnings would be 5.2 percent. The forest manager who has many of these super-vigor trees--and they are quite common--could as a general rule allow such trees to grow 2 inches beyond that allowed by table 3 before considering them financially mature.

Simplified Marking Guides

Before the data and methods developed in this paper can readily be put to use in the woods, simplified marking guides based on them must be set up.

For best results, each manager would work out guides to fit his own conditions. To do so, however, is not a simple matter and requires the services of an experienced technical forester. Table 6 has been developed for average conditions. Here are listed for each vigor class and three common alternative rates of return the largest sizes of trees that should be left to grow one more 10-year period. The diameter spread allows for differences in log height and grade; the user of the tables must exercise judgment in favoring the more promising trees.

In general, low-vigor sweetgums are financially mature regardless of diameter. All sweetgums 22 inches d.b.h. and larger that show no promise of developing better than a grade-3 butt log should be harvested, as should all red oaks of similarly low quality 24 inches or larger.

Table 6.--Simplified marking guides for a 10-year cutting cycle

Vigor class	Alternative rate of return		
	3 percent	4 percent	5 percent
	- - D.b.h., inches - -		
	RED OAKS		
High	32-35	28-30	25-27
Medium	29-30	26-27	22-24
Low	24-25	21-22	19-21
	SWEETGUM		
High	31-33	26-29	23-27
Medium	26-28	22-25	20-22

In applying the simplified guides, the principles relating to other trees, discussed in the foregoing section, should be recognized. Trees of less than high vigor, when they are to be released by cutting sufficiently to improve growth, should be promoted one vigor class before financial maturity is judged. Those trees which show promise of improvement in vigor class, grade, or stem length should be permitted to grow at least another cutting cycle. Where one of two competing trees is to be cut, it is best to take the one of lesser size, grade, or vigor; or the one with poorer prospects for improvement.

These guides are by no means the final answer for each forest manager. They can, however, be adapted and further simplified for any given operation. Moreover, the general method outlined in this paper should enable the forest manager to develop similar guides for other commercial hardwood species.

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USE OF LOW-ALTITUDE CONTINUOUS-STRIP AERIAL PHOTOGRAPHY IN FORESTRY

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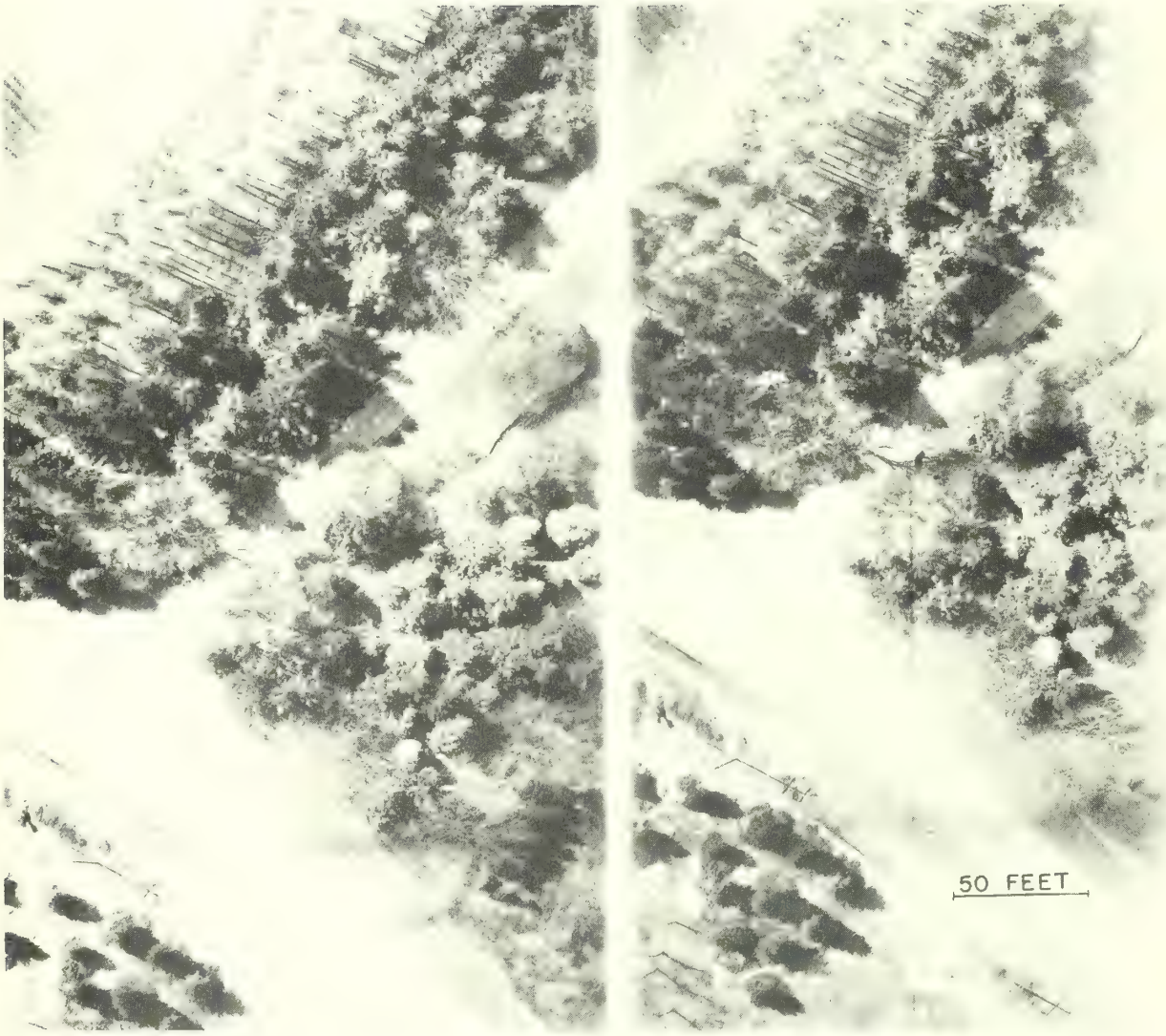

Figure 1.--Stereogram consisting of a cross section of a continuous-strip photograph. Plane's line of flight corresponds to the white line separating the pair. Scale of photograph is indicated in lower right corner. (Photo reproduced by permission of the Chicago Aerial Survey Company.)

USE OF LOW-ALTITUDE CONTINUOUS-STRIP AERIAL PHOTOGRAPHY IN FORESTRY

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Foresters learning of the spectacular wartime achievements of continuous-strip aerial photography immediately speculated on its possible application to their own profession. This new aerial photographic technique had given measurements of water depth to within a few inches. In one instance the large-scale photographs from the Sonne' camera, as it is usually called, revealed an enemy command post when communications wire was seen leading to its carefully camouflaged position. The camera permitted fast, low-flying military aircraft to make photographs of remarkable detail and clarity to scales as large as 1/300.

To determine the feasibility of the new technique in forestry, a study was made of a photograph of an area in the second-growth upland longleaf pine type in south Alabama 1/. Results indicate that at present continuous-strip photography is not well suited to forest mensuration. It probably will never prove practical where large areas must be covered in their entirety. Where sampling suffices, however, some modifications in methods and equipment may enable the Sonne' camera to deliver pictures that contain more information than conventional aerial photographs do.

1/ The photograph used in this study was supplied through the cooperation of the U. S. Naval Air Training Center of Pensacola, Fla. The Chicago Aerial Survey Company generously provided a special stereoscopic viewer. Much valuable information was supplied by the following authorities on continuous-strip aerial photography: Prof. Robert N. Colwell, School of Forestry, University of California; Colonel George W. Goddard, U. S. Air Forces; Mr. E. W. Fuller, President, Chicago Aerial Survey Co.; Mr. Phillip S. Kistler, Seaboard Oil Company; Commander Valentine Van Keuren, U. S. Naval Photographic Interpretation Center. The writer is grateful to Prof. John Carow and Dr. S. A. Graham for their valuable criticism throughout the study, which was originally made at the School of Forestry and Conservation, University of Michigan, in partial fulfillment of requirements for the degree of Master of Forestry.

Principles of Continuous-Strip Photography

The original model of the continuous-strip aerial camera was dedeloped about 1936, by Fred Sonne' of Chicago (9) 2/. Later work by both the Army and the Navy in conjunction with the Chicago Aerial Survey Company resulted in a double lens camera which permits stereoscopic viewing of paired photo strips which are photographed side by side on the same film base.

The Sonne' camera is an adaptation of the old panorama or circuit camera. The film moves continuously past a fixed focal plane slit that is constantly open during the period of photography. The slit, although located in the focal plane, should not be confused with a shutter.

The film, which moves backward (6) with respect to the plane's forward motion, is synchronized in speed according to the following relationship (5):

$$\frac{\text{Film speed}}{\text{plane's ground speed}} = \frac{\text{focal length}}{\text{plane's altitude above ground surface}}$$

A photoelectric scanner mechanism, activated by light from the most intense reflecting surface beneath the plane, automatically maintains the film-ground speed synchronization very closely, even with changing air speeds and over rough terrain (5).

At the instant that any particular section of the film is being exposed, the image from the continuously open lens is sweeping across the open focal plane slit with the same relative speed and direction as the film (figures 2 and 3, appendix). Although both the image and the film are moving, they are stationary with respect to each other. The end result is a continuous strip of photography $9\frac{1}{2}$ inches wide and up to 200 feet in length. Exposure time is a function of slit width, lens opening, and the speed at which the film is moving. Since film speed is fixed by the height and speed of the plane, only slit width and lens opening are adjustable once plane height and speed are fixed. This is not a serious limitation, since excellent photographs have been made at relative speeds up to 1,000 m. p. h. and from altitudes as low as 200 feet (2, 3, 5). Effective exposure times can be as long as 1/10 second. One special test permitted satisfactory photography forty minutes after sunset with an exposure of $\frac{1}{4}$ second (3).

Stereoscopic photography is obtained by using different lenses to expose the right and left hand halves of the slit. A small rotation of a double lens turret directs one lens forward and the other backward with respect to the slit. Thus with the camera in a vertical position

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2/ Underscored numbers in parentheses refer to Literature Cited, page 12. Original information not otherwise acknowledged is from personal communications to the author.

the forward lens photographs an object on one-half of the film before the plane passes over it, while the rear lens records the same object again on the other half of the film after the plane has passed over. This arrangement results in two separate and parallel continuous-strip photographs on the same film base, with each strip occupying half the total film width as shown in figure 1, which is a representative cross section of black and white strip photography. The two lenses may be rotated from a zero-degree to a 20-degree stereo lens angle in control of parallax. A 5-degree angle gives normal stereoscopic values for the average observer (5). A special mirror stereoscope is used for viewing.

The photographs are made as standard black and white prints or as color transparencies.

Study Methods

The study consisted of a comparison of photographic measurements with field measurements of the identical trees and conditions shown by selected areas on the photograph.

The photograph was made in the spring of 1948. The four sections of the film that were studied represented plots slightly over 1½ acres in size. The number of trees (4½ feet tall or taller) per plot ranged from 27 to 47. The photo scale varied for the four study areas, ranging from representative fractions of 1/658 to 1/771, or from one inch equals 55 feet to one inch equals 64 feet.

The photography was recorded on Kodacolor Aero Reversal film, a color transparency type. The stereo lens angle was 5 degrees. Camera focal length was 100 millimeters or 3.937 inches. For this strip, one lens was pointed vertically downward while the other pointed ahead of the airplane. The advantage of this innovation was that displacement could be measured simply by scaling inward at right angles to the center line of the vertical strip photograph.

A special mirror-type stereoscope was furnished by the Chicago Aerial Survey Company, the original manufacturers of Sonne' equipment.

Results

The impression gained from a casual examination of a continuous-strip photograph is that here must certainly be a source of precise and detailed information. The photograph, particularly when in color, is almost spectacular in the amount of qualitative detail to be found in some places. Visions of armchair forestry deluxe were shattered, however, when the photograph was closely examined and measurements were attempted. It was found that most measurements were hampered by two shortcomings in the photograph--blurring, and severe variations in the scale with slight changes in the altitude of the camera above the object. These defects will be discussed in a later section of this paper.

Field check of continuous-strip photo interpretation was made for the following variables: species identification, stem counts, height measurement, crown measurement, d.b.h. measurement, site evaluation, and distribution of reproduction.

Species identification

The writer had a general knowledge of the photographed area before the field check was made. On the basis of this knowledge, the photo allowed identification of longleaf pine (*Pinus palustris*), slash pine (*P. caribaea*), flowering dogwood (*Cornus florida*), magnolia (*Magnolia grandiflora*), and sweetbay (*Magnolia virginiana*). Of the shrubs, only gallberry (*Ilex glabra*) could be determined with some certainty. Oaks could be identified as a group only.

The field check confirmed the above determinations, but it did little to provide a reliable photo key to identification of other species in the pictures. Of the oaks, only blackjack (*Quercus marilandica*) had a fairly consistent color and texture pattern. Southern red oak (*Q. falcata*) was extremely variable in color, texture, and form, but in this stand the larger specimens could be recognized by their form and size alone. The other commonly occurring species were bluejack oak (*Q. cinerea*), post oak (*Q. stellata*), and persimmon (*Diospyros virginiana*). None of these had characteristic colors or patterns on the photograph. The three yellow-poplar (*Liriodendron tulipifera*) trees found in the photograph had a consistent color and pattern.

Where the ground was not blurred, longleaf pine reproduction over one foot in height was easily distinguished by its unique form. Slash pine reproduction was also identifiable, as was small flowering dogwood from its characteristic yellow-green color. Oak reproduction could not be identified from the pictures even with a field check.

In poorly stocked or completely open areas the grass and other small plants were usually defined sharply. If the interpreter had made field-photo comparisons in such areas, he probably could have learned to distinguish species of small plants from the photos alone. It appeared that line-intercept and transect techniques for determining percentage of species composition in ecological and range management studies might be successful.

It is entirely probable that more field comparisons with the photograph would provide clues to species identification that have been overlooked. Species identification is one of the most promising features of this new photographic technique, and the foregoing determination should by no means be considered as final with respect to this particular use of strip photography.

Stem counts

Stem counts were subject to an appreciable error, particularly on the better stocked areas. Of a total of 121 trees on three study areas,

only 99 could be distinguished on the photographs. Most of the trees missed were four inches or less in d.b.h., but there were three instances where a 10-inch longleaf pine tree was completely overlooked. Many of the "misses" were anticipated where clumps of hardwoods were involved. With pines too, it was almost certain that some crown clusters were composed of more than one tree, but the specific number could not always be determined, even with the use of the stereoscope.

If the difficulties resulting from scale variation can be resolved, continuous-strip photography may be used to prepare individual tree location maps for detailed silvicultural studies of under-stocked areas. A number of such maps were made, and the average time required to sketch a half-acre plot at an approximate 1/700 scale was 20 minutes.

Height measurements

Heights of trees were measured in three different ways: By the length of the tree shadow, by the method of displacement, and by the method of parallax difference.

The shadow method was completely unsuccessful, since the photography had been done near mid-day and shadows were too short for accurate computations. The fact that older longleaf pine crowns are often rounded further complicated such measurements. However, in some timber types shadow measurement might be the most accurate method of height measurement on these large scale photographs.

Height measurement by parallax difference and displacement was more successful, but it was not accurate enough to be used with a sampling technique. Had records of plane ground speed and film speed been available, more accurate height computations might have been made with the velocity formula (see appendix pp. 13 and 17), which automatically removes errors in altitude and film speed synchronization.

Parallax method.--The term parallax denotes displacement of one object with relation to another. In this case the displacement is that between the two images of the same object measured parallel to the line of flight. The amount of parallax or parallax difference is a measure of the height of the object.

A "floating mark" type comparator is manufactured by the Chicago Aerial Survey Company for measuring the parallax difference but was not available for the study. The Harvard parallax wedge principle was therefore adapted by the method described in the appendix, page 17.

Height determinations were made for selected trees in three of the study plots. The same trees were then measured with an Abney level. As table 1 in the appendix shows, the errors ranged widely and at random. Trees selected for these comparisons were those that offered the best chance for measurement by this method; consequently, it is unlikely that measurement of additional trees would show any increase

in accuracy. Results might have been better with the special "floating mark" comparator, but when the tree top is blurred, as it often is, accuracy would be impossible with even the best equipment.

Displacement method.--Along the outer part of the film strip some isolated trees are exposed from base to crown tip. This displacement effect is similar to the view of trees seen from a lookout tower--near the tower only the crowns can be seen, while more and more of the trunks become visible as trees farther from the tower are viewed. In the photo, limbs, crook, and even some large defects were apparent where blurring did not interfere. The number of trees so exposed was small, however, and most of them were open-grown, low-quality stems.

Since one of the stereo strips was taken with a vertical lens, displacement was conveniently measured on it by scaling distances at right angles from the strip center line to tree tops and bases. A specially made micrometer wedge reading up to 2.50 inches by 0.01-inch graduations was used. The procedure for converting these measurements to height is given on page 18 of the appendix.

The results (see table 1 in appendix) were somewhat more accurate than those of the parallax method, with the truest measurements being derived from trees whose bases and crown tips were most clearly defined. It is apparent, however, that the degree of accuracy is still far from satisfactory.

Crown measurements

The most striking single feature of the strip photographs is the sharply defined detail of some of the tree crowns. Individual needle clusters are apparent on the pines, and the new terminal growth or "candles" of the longleaf pine show with unusual clarity. In some cases the staminate cones are visible. Crown vigor can also be assessed from the foliage density, and, in this photo, color. One group of slash pines was seen to have browning foliage. The cause was normal needle cast in conjunction with new spring growth, but apparently insect infested trees with yellowing foliage could be easily spotted on color photography of this type.

Crown diameters could be accurately measured from the photos if the scale were known. Even then the height of the maximum crown dimension would have to be measured so that scale corrections might be made for crown level. For example, maximum crown width might easily be 50 feet above the tree base. With the plane at 250 deep above the tree base, there would be a 20 percent change in the scale value from tree base to point of maximum crown width. Each tree crown would therefore require a separate measurement to determine scale correction at the point of its maximum width, and, since height measurements proved to be erratic, it would be difficult to determine the height of maximum crown width.

In well-stocked stands it is sometimes difficult, even with a stereoscopic viewer, to determine individual crowns and crown tips. Near the edges of the film the extreme displacement often superimposed crowns and stems into such a jumble that stem and crown features were largely obscured or were unassignable to individual trees.

Diameter measurements

Since few trunks can be clearly seen, diameter measurements are generally impractical on present Sonne' photography. However, measurements were attempted on seven trees that were along the outer edges of the photo strip, and whose lower trunks were clearly visible.

One of the trees measured was 7 inches d.b.h. and the others ranged between 11 and 15 inches by field measurement.

A micrometer wedge 3/ reading to the nearest 0.001 inch was used to measure the d.b.h. The photographic distance from the tree base to the point representing d.b.h. varies with camera altitude and the displacement of the tree from the center line of the strip photograph. The d.b.h. point is computed from a geometric relationship similar to that used in measuring tree heights by displacement (see appendix, page 19).

Computed diameters ranged from 16 to 62 percent greater than the corresponding field measurements. The most probable source of error is the usual tendency for the ground zone to be slightly blurred by image movement resulting from mis-synchronization of film speed; this would result in measurements larger than the true ones.

Site evaluation

Aside from the fact that it covers only a limited area, Sonne' photography offers distinct advantages over conventional aerial photography for site evaluation. All of the principal criteria (10)--topography, soils and geologic formations, vegetation, and total height-crown diameter ratio--are much more evident on the large scale photographs, even when blurring and scale variations are considered.

Distribution of tree reproduction

In understocked areas where there was usually little blurring, tree reproduction and other small vegetation were seen clearly. The Sonne' camera can also be used to advantage in areas where there are few tall trees to change the film speed synchronization to that of the upper crown canopy.

3/ The wedge was Timber Survey Aid No. 2, from the Pacific Northwest Forest and Range Experiment Station, 423 U. S. Court House, Portland 5, Oregon.

No plantations are included on the film studied, but it is evident that the photographs could be used advantageously in survival counts and other studies of extensive plantings. Blurring would not occur until tree heights exceeded the limits outlined below, and excellent counts could be made on the regular pattern of a plantation.

Blurring and Scale Variation

Blurring

Correspondence with Kistler and Colonel Goddard indicates that blurring is mainly an effect of film speed synchronization. The electrical scanner picks its cycle from the strongest ground image. Thus, in a well stocked area, the light image actuating the scanner would come mainly from the crown canopy, and the film speed would be adjusted accordingly. Since the tops of trees have greater angular velocity with respect to the camera than the ground below them, the film is moving too rapidly to define clearly the lower openings that appear from time to time in a heavy canopy. Conversely, in understocked areas the main scanner impulse comes from the ground, and the tops of scattered tall trees will be blurred.

Kistler observes that the depth of focus varies with focal plane slit width and f/stop. However, he states that the clearly defined zone would average between 1/5 to 1/10 of the plane's altitude above ground. This means a sharpness zone of only 20 to 40 feet when the plane is at 200 feet. Colonel Goddard estimates approximately the same zone of sharpness. He states that "objects whose images would require a five to ten percent change in film speed to be in perfect synchronization, are recorded satisfactorily in spite of their being somewhat linearly distorted along the line of flight."

By using the relationship that

$$\frac{\text{film speed}}{\text{plane's ground speed}} = \frac{\text{focal length}}{\text{plane's altitude}}$$

it can be shown that at 200 feet above ground a plus and minus change of 10 percent in film speed with all other factors constant would give a sharpness zone ranging from 182 to 222 feet, a spread of 40 feet. If the scanner were picking its cycle from the ground only, 200 minus 182, or 18 feet, would be in the sharpness zone. If actuation of the scanner is from an intermediate crown canopy at least 18 feet above the ground, the full zone of 40 feet would be available. For the film studied the sharpness zone seems to correspond closely to these relationships. Blurring can be greatly reduced or eliminated by higher altitude flights, but this would produce smaller scale photos unless a camera with longer focal length were used.

Scale variation

In military reconnaissance with automatic film speed synchronization the altitude of the plane need not be constant provided that records are made during photography of film and plane speed. These records, when correlated with the film index numbers that are stamped at 8.15-inch intervals along the film margin, make it possible to compute photo scale at each index point. Such records were not available for the photography studied. Instead, the scale was calculated from ground measurements of distances between objects identifiable on the film.

If the airplane's altitude remains constant, topographic changes still result in large variations in scale, even over gently rolling terrain. For example, with a 100 mm focal length camera in a plane flying at 200 feet, a ground rise of 25 feet will change the photo scale from 50.8 feet per inch to 44.5 feet per inch, a 12.4 percent linear change. If sample plots were being measured, the change in area would be 23.3 percent. As has been pointed out, such changes in scale also make it very difficult to determine the true size of tree crowns from a Sonne' photograph.

If the Sonne' camera were to be used in relatively level country, numerous ground measurements would be needed for scale determination unless accurate flight records of film speed and the plane's ground speed were taken. In rugged terrain, strip photography would be ruled out, at least for large scale photography. Higher camera altitudes would reduce percentage variation in scale, but in turn scale would be reduced, diminishing the advantage of strip over conventional photography.

Further work with continuous-strip photography should be done with longer focal length cameras. Colwell points out in correspondence that such cameras would largely remedy excessive scale variation and blur as well as the excessive lateral displacement of images near the film edge. One disadvantage of longer focal lengths would be to restrict further the already narrow strip of ground covered by the photographs.

Availability and Costs of Continuous - Strip Photography

The only commercial firm that makes continuous-strip photographs at present is the Chicago Aerial Survey Company of Chicago, Illinois. This concern states that costs of Sonne' photography must be estimated for each individual job. No schedule of approximate costs is available, but the company will furnish cost estimates for specific jobs.

Since color photography has certain advantages over black and white prints, the question of the added cost of color film arises. On the basis of costs furnished by the Eastman Kodak Company (1949) the following comparisons are made for 150-foot rolls of $9\frac{1}{2}$-inch width film.

Kodacolor Aero Reversal		Infrared Aerographic	
$ 270.20	Film	$ 77.20	Film
27.02	Tax	7.72	Tax
11.80	Processing chemicals	52.50	Materials to develop and print: Estimated at 35¢ per foot
$ 309.02	Total	$ 137.42	Total

$\frac{\$\ 309.02}{150 \text{ feet}} = \$2.06$ per foot

$\frac{\$\ 137.42}{150 \text{ feet}} = \$0.92$ per foot

Since film is usually a very minor part of the costs of aerial photography, it is apparent that color film at $2.06 per foot--or slightly more than twice the cost of black and white--is not prohibitively expensive.

Conclusion

Sonne' strip photography today has limited application to forestry. Fuller states in correspondence that "it has of course the elements of ultimate accuracy but could not at present be used for measurement of tree heights in general or wood volume." Kistler also pointed out that not much accuracy should be expected without exact scale control from ground measurements.

The present short focal length camera with automatic film speed regulation can probably be used in sampling understocked forest areas and large plantations, in site evaluation, in assessing range conditions, and in ecological studies when the subject photographed is not partially obscured by a tree crown canopy and when the height of the subject does not exceed approximately 1/5 the plane's altitude above ground.

Colwell has suggested making stand volume rather than individual tree volume measurements. This approach was not investigated, but it appears to be a promising means of using the strip photographs for tree volumes.

At best, continuous-strip photographs are never likely to be practical where complete area coverage is needed, for their extremely large scale is achieved at a sacrifice of area covered per flight strip. It appears that the technique will be confined to sampling procedures which require more detailed information than that obtainable from conventional pictures.

Within these limitations, however, the development of a Sonne' camera adapted to forestry work is entirely feasible.

Colwell suggests that longer focal lengths than are used today would permit photography at the same advantageously large scales but from altitudes high enough to reduce the effect of angular velocity blurring. Latest information indicates that longer focal length cameras have been developed and used successfully, but there has been no application of this equipment to forestry. Kistler also points out that flights made with consideration for the specialized requirements of forestry might eliminate some of the present shortcomings of strip photography. For example, a great deal of blurring might be eliminated by experimenting with the focal plane slit opening to find the absolute practical minimum width.

A Sonne' camera adapted to forestry work would have certain advantages in addition to those obtaining from the large scale. For one thing, more flying weather would be available. The low plane altitudes permit photography under cloud and haze conditions which prohibit exposures from the greater altitudes required in conventional aerial photography. The greater latitude in exposure time would permit photography under adverse light conditions.

Aerial cameras with conventional type shutters have been developed which apply the Sonne' principle of compensation for image motion (2, 3). The entire film magazine moves in synchronization with ground speed during the exposure period, and then returns to normal position. Such cameras appear to hold promise for forestry work and should be investigated.

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Appendix

Geometry of continuous-strip photographs

The formulae used in the interpretation of the continuous-strip photograph are dependent on the fact that a line of sight projected from the focal plane slit through either lens makes a constant angle with respect to vertical and horizontal objects as the airplane moves forward in level flight. Thus the height change per unit of parallax is constant for a given altitude and stereo lens angle. This is shown diagramatically in figures 2 and 3.

Height by parallax difference measurement

The geometric relationships shown in figure 2 are the basis for the following vertical height formulae as developed by Kistler (5).

(a). $\frac{h}{\frac{1}{2}P} = \cot a/2$

from which

(b). $h = \frac{P}{2} \cot a/2$

The following relationship also is derived:

(c). $\frac{P}{p} = \frac{H}{F}, \quad P = \frac{pH}{F}$

Substituting for P in the formula (b).

(d). $h = \frac{pH}{2F} \cot a/2$

In all the above

a = Stereo lens angle
H = Altitude of camera above datum
F = Focal length of camera
p = Difference in parallax on the photograph
P = Difference in parallax on the datum plane
h = Height of tree or other object
T = Total or absolute parallax

From figure 2 it is seen that $\cot a/2 = \frac{F}{T/2}$. Substitute this in the formula (d) to give

(e). $h = \frac{pH}{2F} \times \frac{F}{T/2}$

which reduces to

(f). $h = \frac{pH}{T}$

Formula (f) was used for parallax difference height calculations. H was known from a comparison of ground-photograph measurements and p and T were measured directly from the photograph. Results of height measurement by this method are compared with corresponding field measurements in table 1.

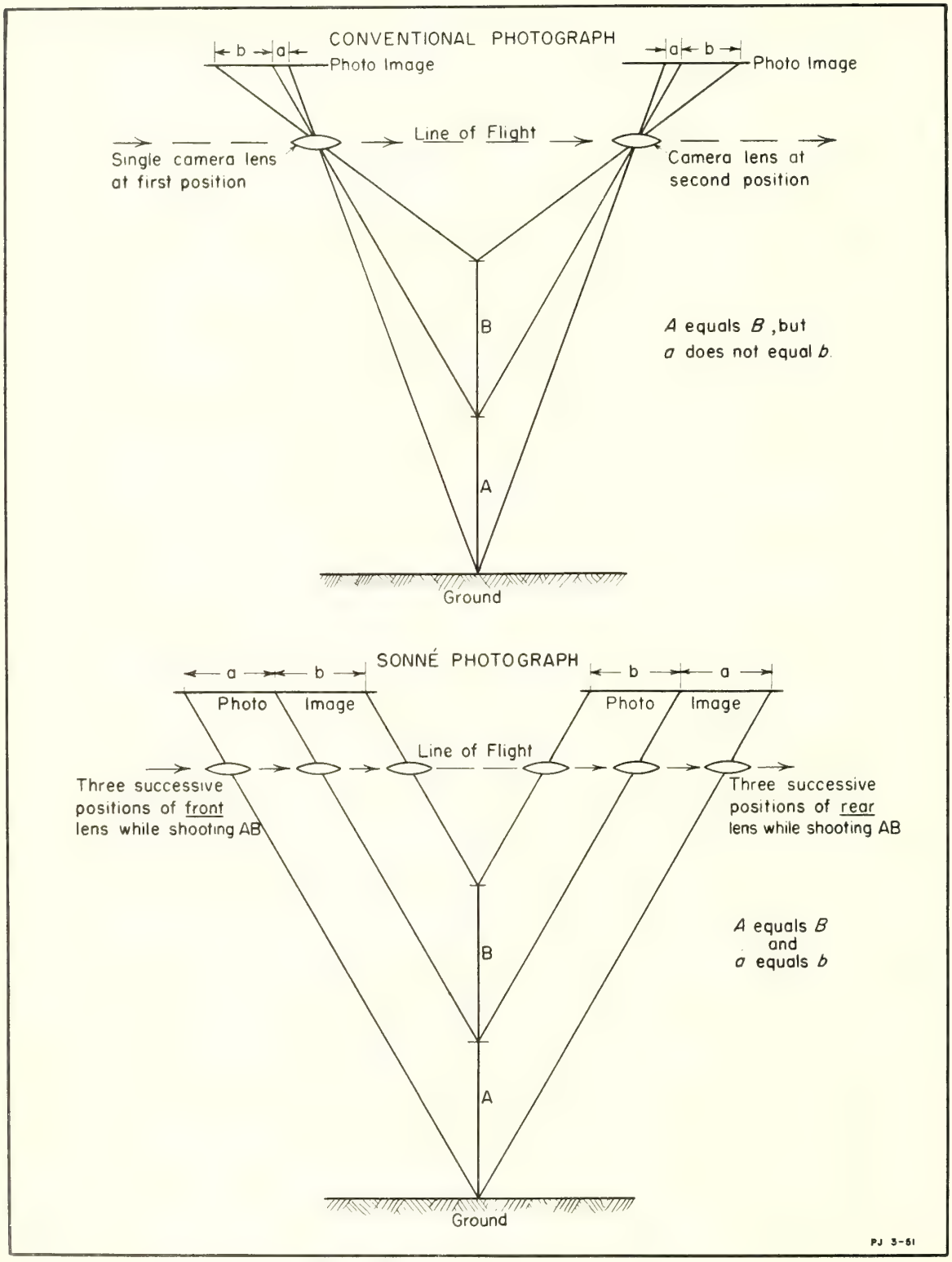

Figure 2.--Continuous-strip and conventional photographs compared schematically.

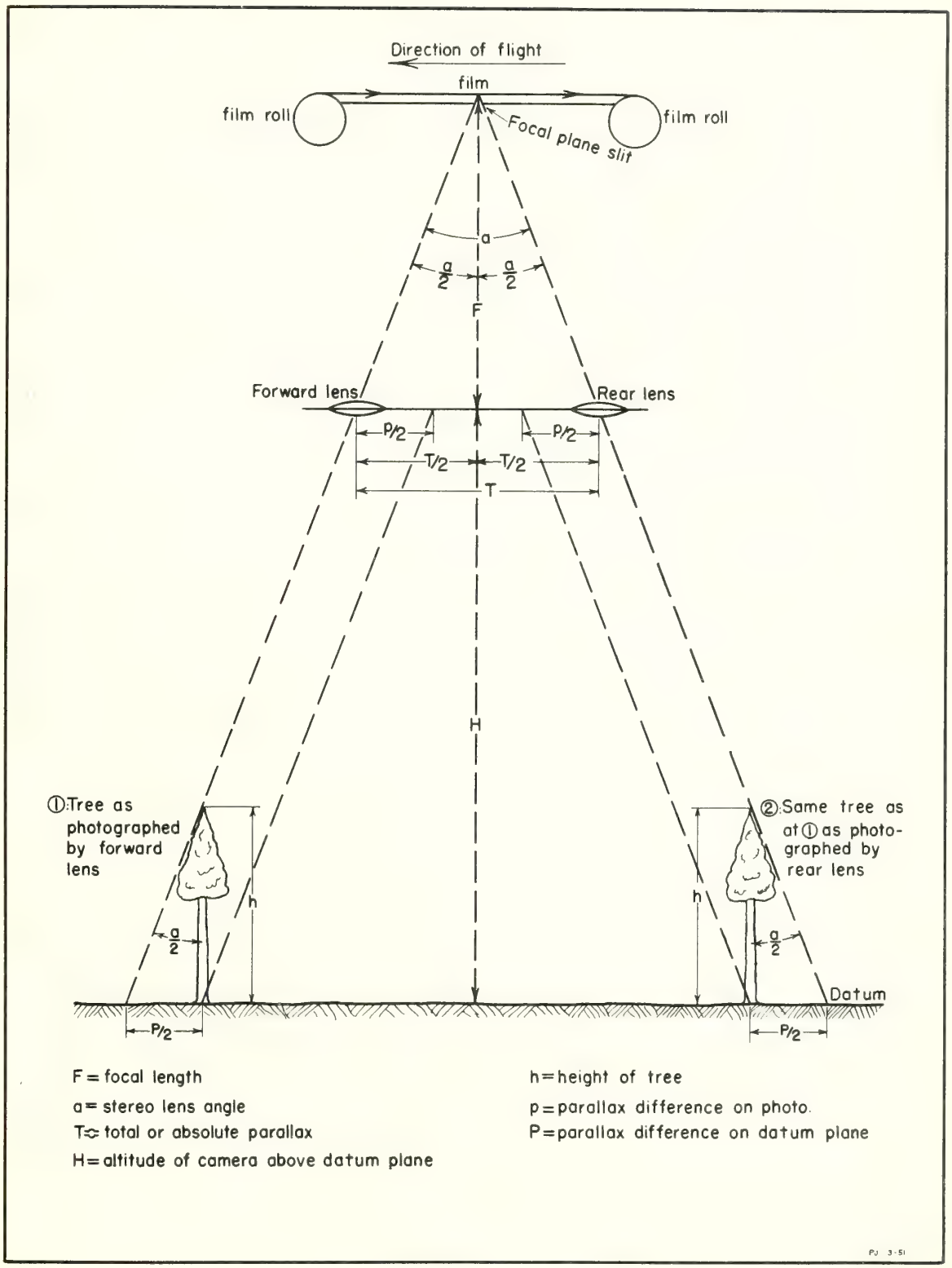

Figure 3.--Schematic diagram of Sonné camera.

Table 1.--Computed tree heights compared with field measurements (in feet)

Tree number	Height from field measurement	Computed height: Kistler's parallax difference formula	Computed height: Displacement
Area 1			
1	35	51.2	(1/)
7	65	87.4	(1/)
8	67	67.1	(1/)
15	59	58.1	(1/)
16	27	23.6	(1/)
17	(2/)	113.0	78.6
18	(2/)	82.5	83.7
20	60	95.3	76.5
24	29	34.0	17.4
25	15	12.5	25.4
Area 2			
9	68	58.2	62.0
12	67	67.6	74.5
13	62	67.6	(1/)
18	70	65.2	(1/)
21	46	41.1	48.8
24	7.3	8.9	10.5
26	8.6	7.0	11.0
30	59	57.0	(1/)
31	35	31.0	(1/)
38	49	36.1	(1/)
Area 3			
8	56	41.8	64.5
10	23	19.5	(1/)
15	62	79.5	(1/)
17	44	68.5	(1/)
28	65	78.5	76.2
31	55	76.1	49.8
32	38	53.5	45.7

1/ Measurement was impossible.
2/ No field data available.

As indicated earlier in the text, formula (f) makes no correction for errors in altitude and film speed synchronization, and these errors are reflected directly in the computations. Kistler (5) states that the only really practical parallax height measurements are made with a velocity formula:

$$\frac{dh}{dp} = \frac{Vp}{2Vf} \cot a/2$$

Where $\frac{dh}{dp}$ = height per unit of parallax

Vp = Ground speed of plane

Vf = Film speed

This formula automatically eliminates errors of altitude and synchronization. The only remaining error is the difference between air speed and actual ground speed, and this error becomes almost negligible at high airplane speeds.

Thus if special flights are made with longer focal lengths to reduce blur, and accurate film and ground speed records are kept, it may be possible to make tree height measurements of acceptable accuracy.

The Harvard parallax wedge, developed by Spurr (10, 11), was adapted for use with the continuous-strip photography by the following procedure:

The wedge was drafted on cellulose acetate material and was graduated in dots, each of which corresponded to 0.0084 inch of parallax difference. A more accurate wedge could have been made by photographic reduction, but it was found that much larger errors than those of the wedge were introduced through scale variation and blurring. Hence, the wedge used was considered satisfactory since it gave consistent readings with different operators.

In effect, the standard wedge was divided along a straight line midway between the rows of converging dots, and one of the rows was then moved forward, still in the same plane, without changing the side-wise spacing between the rows or the angle of convergence of the rows. Also, since the stereo strips are fixed, the distance between the converging lines was necessarily accommodated to the absolute parallax, which was 0.365 inch on the photography used.

The concept of absolute or total parallax and base length is unique in the case of stereoscopic strip photography. Since there is no fixed principal point as in conventional photographs, the absolute or total parallax is the distance between identical points on the strip pairs measured parallel to the line of flight (10). This is also called

the base length. A series of 32 such measurements at random points along the part of the film studied gave the mean base length or total parallax of 0.365 inch .

Height by displacement measurement

Tree height measurement by the displacement method employs the same formula used for conventional photos except that measurements are made from the center line of the strip since there is no nadir or plumb point in the sense of ordinary photographs.

As given by Spurr (10) the displacement formula is

$$\frac{d}{r} = \frac{h}{H} \text{ or } h = \frac{dH}{r}$$

where

h = Height of tree in feet
d = Length of tree image in inches
r = Distance from top of tree image to center line in inches
H = Height of the airplane above tree base in feet

All displacements were measured on the strip as photographed by the vertical lens. This made it possible to measure d and r at right angles to the center line. As pointed out previously, the usual Sonne' photograph is made with one lens pointing ahead and one lens pointing to the rear of the line of flight. Such photography would make measuring displacement more difficult since the distance r from top of the tree to the center line would be measured at an angle other than 90° from the center line. This angle would vary with the distance of the tree base from the center line.

The results of measurement by the displacement method are compared with field measurements for identical trees in table 1 of the appendix.

Diameter breast height measurement

A modification of the displacement formula was used to establish the d.b.h. point for measurement with a micrometer wedge. Figure 4 shows the geometric relationships involved (10).

From this it is seen that

$$\frac{d}{d + r'} = \frac{h}{H}$$

By algebra this gives

$$d = \frac{hr'}{H-h}$$

In this formula

- h = 4.5 feet (d.b.h. point)
- H = Height of the plane above the tree base
- r' = Least photo distance from center line to tree base
- d = Photo distance from tree base to d.b.h. point

Diameter measurements were made on the photographic strip taken by the vertical lens. As in the case of the displacement measurements for height, this made it possible to scale photo distances at right angles to the center line of the strip.

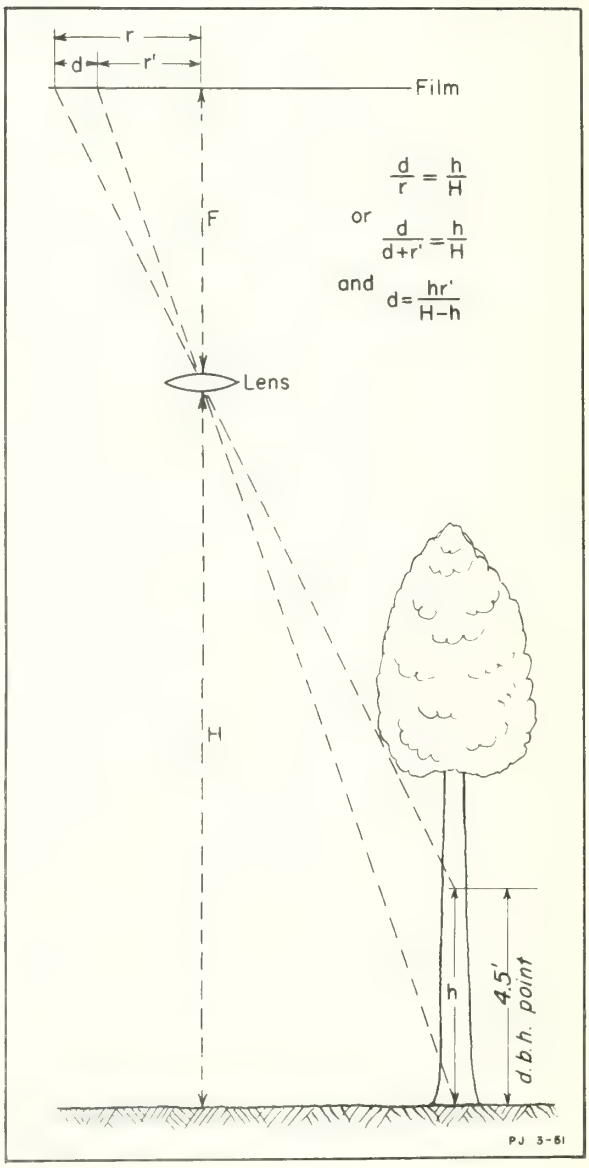

Figure 4.--Determination of d.b.h. point on film for micrometer wedge measurement.

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ROOT-ROT CONTROL AND SOIL IMPROVEMENT AT THE ASHE FOREST NURSERY

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ROOT-ROT CONTROL AND SOIL IMPROVEMENT AT THE ASHE FOREST NURSERY

By

T. E. Maki and Berch W. Henry 1/

The Ashe Nursery near Brooklyn, Mississippi, was established by the United States Forest Service in 1936 on previously unbroken forest soil, classed as a good phase of Ruston fine sandy loam. From the beginning, root rot of undetermined origin caused heavy cull losses of all four species of southern pines (*Pinus palustris*, *P. caribaea*, *P. taeda*, and *P. echinata*). Even apparently healthy stock showed inferior survival in tests with seedlings from other nurseries. Heavy damping-off (especially sand-splash of longleaf), low fertility, and excessive erosion also hampered production.

"Resting" the nursery during the war did not alleviate the root rot. The first seedling crop after production was resumed in 1945 was heavily diseased, and this, together with the earlier evidence of inferior survival, caused the Forest Service to withdraw the nursery from production until remedies could be found.

1/ Respectively, Officer-in-charge, Gulfcoast Branch of the Southern Forest Experiment Station, and Pathologist, Division of Forest Pathology, Bureau of Plant Industry, Soils, and Agricultural Engineering. The authors gratefully acknowledge the unstinting help of R. M. Allen and E. R. Ferguson, who carried out most of the nursery experiments on soil fertility phases, supervised all plantings, made the field examinations, compiled all of the data on soil fertility phases, and prepared many of the basic reports; of Dr. Paul V. Siggers, who made the diagnoses on diseased material and assisted in the early installations on root rot control; of Dr. R. M. Lindgren, who installed the initial pathology tests and who has furnished general supervision and technical guidance generously throughout the whole investigation; and of Nurseryman G. F. Erambert and the Ashe Nursery staff, who carried out all routine nursery operations and without whose full cooperation the successful conclusion of the study would not have been possible.

In November, 1946, the Southern Forest Experiment Station and the Division of Forest Pathology 2/ in cooperation with the Mississippi National Forests undertook intensive studies aimed at eliminating the root rot and improving survival of seedlings from the nursery. This report summarizes the results and also the recommendations that were made for controlling root rot and for improving soil fertility at the nursery.

Scope of Past Work 3/ and Present Studies

Unexpected losses in the first crop of seedlings at the Ashe Nursery were called to the attention of the Division of Forest Pathology in late 1936 by the Forest Service. For several years thereafter, preliminary investigations were made, but neither personnel nor finances were available for an adequate and continuous attack on the problem. However, among the valuable indications obtained were strong evidence (1) that the disease was infectious and that an organism or organisms were the likely cause; (2) that a combination of soil disinfection and fertilization probably would reduce the disease and increase seedling size. In pot cultures, the disease was found to develop on seedlings sown in soil from infected areas of the nursery. Disinfection of the soil by saturating it with formaldehyde gave disease-free seedlings, but if pieces of infected roots were added to the disinfected soil the disease appeared again. Numerous isolations from infected roots revealed several fungi to be commonly associated with the rot. One of these, *Torula marginata*, showed some killing of roots when inoculated into soil. Limited experiments indicated that diseased plants were less likely to survive the first year in the field than were healthy plants.

In the early work, no systematic effort was directed toward improvement of soil fertility, although formal tests demonstrated the inferior survival of the Ashe stock as compared to stock from several other nurseries. Some of this inferiority might have resulted from planting stock that was moderately affected with root rot. Nevertheless, by 1939 there was a general feeling that inadequate fertility, perhaps a phosphorus deficiency, also was partly responsible for the poor performance of Ashe stock.

The present study began in November 1946, when 3 beds of longleaf pine were sown on the first area in which severe root rot had been observed. By the spring of 1949 a total of approximately 110 standard nursery beds ($4\frac{1}{2}$ feet by 400 feet) had been sown to longleaf,

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2/ Bureau of Plant Industry, Soils, and Agricultural Engineering, U. S. Department of Agriculture.

3/ Based on office reports and correspondence by Drs. Bailey Sleeth, P. V. Siggers, and Carl Hartley, in the files of the Division of Forest Pathology. This early work also was summarized in a report "Root Rot at the Ashe Nursery, Brooklyn, Mississippi", October 15, 1946, by Dr. Curtis May of the Division of Forest Pathology.

slash, and loblolly pine in various tests on root-rot control and improvement of soil fertility. These beds produced an estimated three and a half million seedlings of plantable size. Over 200 thousand sample seedlings were individually handled or examined, and of these, over 100 thousand had been outplanted by December 1949 in well-replicated experimental plots on the Desoto National Forest.

Root Rot

The large number of individual tests in the study makes it impractical to report on each of them. Only enough tabular material is included to illustrate the nature and magnitude of response to the different treatments.

Occurrence, nature, and effect

Study of root rot was confined to three pine species, longleaf, slash, and loblolly. All were susceptible to root rot, but not equally so. In spots where the disease was severe, loblolly showed 50 percent mortality in the seedbed; and spring-sown longleaf was not worth lifting because 90 percent or more of the seedlings had to be culled for tap roots and scarcity of laterals. In such spots 95 percent of the slash pine were sometimes affected, but seedbed mortality was usually light, and cull percent never approached the extreme mentioned for spring-sown longleaf.

The rot was unevenly distributed through the nursery. Tests in four out of ten 9-acre compartments have shown that the disease was heavy in compartment 7 (where it was first observed), moderate in compartment 2, and very light and spotty in compartments 5 and 6.

The rot could not be detected by surficial examination of seedbeds. Badly infected seedlings often attained large size and their foliage and shoots appeared vigorous.

In grading seedlings for outplanting tests, six classes of rot were recognized for longleaf pine, five for slash and loblolly.

These classes are:

1. Healthy.
2. Up to 25 percent of tap root surface affected.
3. 26 to 50 percent of tap root surface affected.
4. Over 50 percent of tap root surface affected.
5. Lower part of tap root dead, and proliferation of laterals from live portion.
6. Entire tap root surface affected, and 3 or less living laterals; occurs only in longleaf.

In general, the more severely longleaf seedlings were infected, the poorer they survived in the field (table 1). The survival of even the most lightly affected stock was 25 percent lower than that of healthy seedlings. The exception was class 5 seedlings, which frequently had as many or more laterals than were found on healthy ones, so that careful planting allowed fair survival even though the root systems were shallow.

Table 1.--Average survival of outplanted seedlings that showed various stages of root-rot damage when outplanted, but which were plantable on a size basis. All seedlings were from untreated nursery beds

Year planted, species, and time in field 1/	Root-rot class 2/					
	1	2	3	4	5	6
	Percent					
1948 3/						
Longleaf						
5 mos.	89	82	70	59	84	44
12 mos.	77	52	41	28	53	8
Slash						
5 mos.	93	97	96	91	92	...
12 mos.	84	90	91	77	72	...
1949 3/						
Longleaf--4 mos.	93	96	93	82	95	46
Slash--4 mos.	99	99	97	93	100	...
Loblolly--4 mos.	97	98	99	93	99	...

1/ Eight replicates of 25 seedlings each in 1948 outplanting and 4 replicates of 25 seedlings each in 1949 outplanting.
2/ For definition of classes, see page 3.
3/ Results for the 1948 tests in this table are reported as actual mean survival percents; for the 1949 tests, and for all other tests in subsequent tables, unless otherwise specified, the percents refer to mean proportions of seedlings in fair and better vigor--which is roughly equivalent to expected survival at the end of the second season in the field.

Only the more severely affected slash seedlings showed reduced survival after 12 months in the field. From the meager evidence available, loblolly seemed to react similarly to slash. From both condition in the nursery and survival in the field, it appears that the root rot affects spring-sown longleaf most, loblolly next, and slash the least.

Cause of disease

The cause of root rot has proved elusive. There is strong evidence that a nematode-fungus complex is involved. Three species of fungi (*Torula marginata*, *Sclerotium bataticola*, and *Fusarium* sp.) and representatives of at least ten genera of nematodes (*Acrobeloides*, *Ditylenchus*, *Aphelenchoides*, *Panogrolaimus*, *Tylenchus*, *Pratylenchus*, *Discolaimus*, *Dorylaimus*, *Diplogaster*, and *Zeldia*) have been found associated with diseased roots. However, inoculation with various of these organisms, alone and in combination, has not completely reproduced the disease symptoms.

Methods of control

Root-rot control has been attempted with various fertilizers and soil amendments, with varying dates of sowing, with fungicides, nemacides, and an insecticide incorporated into seedbeds prior to sowing. Of these approaches, three have given fair to excellent control:

1. The nemacidal fumigant ethylene dibromide ($BrCH_2 \cdot CH_2Br$) at rates of 30 to 32 gallons per acre of a 20 percent by volume solution (Dowfume W-40);
2. Fall sowing of longleaf; and
3. Sawdust at the rate of 10 or more tons per acre combined with various minerals disked into the surface six inches of soil.

Fumigation.--The nemacidal fumigant, Dowfume W-40, has given the best results; it has consistently controlled the disease in all trials over a 3-year period (1947-1949). Some other soil fumigants have also shown promise (table 2); none have been superior to ethylene dibromide, and none have equalled it in low cost, ease of application, and slight hazard to personnel.

Seedlings from beds treated with ethylene dibromide have, in almost every instance, survived better when outplanted (table 3)--mainly, no doubt, because they were free from disease.

On bed segments given one treatment with ethylene dibromide, roughly 35 percent more plantable seedlings were produced in 1949 than on bed segments left untreated (table 4). Where ethylene dibromide was applied on the same area in two successive seasons without intervening cover and green manure crops, there was no deleterious effect on pine seedlings. Neither was there any appreciable carry-over of disease control to the second pine seedling crop on small plots that received no additional fumigation the second year (table 4). In current nursery practice, at least one year in cover crops would intervene between pine crops. Thus, although it may be necessary to fumigate diseased areas of the nursery prior to each spring-sown pine crop, no harmful effects from build-up of the chemical are anticipated.

Table 2.--Materials used in soil treatments for root-rot control and their relative effectiveness 1/

Fumigants		Non-fumigants	
Chemicals and rate of application per acre	Effectiveness	Chemicals and rate of application per acre	Effectiveness
Ethylene dibromide (20 percent by volume)		Formaldehyde (40 percent by weight)	
25 gal.	3	250 gal.	1
32 gal.	4	Allyl alcohol	
41 gal.	4	20 gal.	1
Methyl bromide gas		30 gal.	1
218 lbs.	3	40 gal.	1
435 lbs.	4	50 gal.	1
870 lbs.	4	Ethyl mercury iodide	
Chloropicrin		150 lbs.	0
41 gal.	3	Salicylic acid	
Dichlorobutene		240 lbs.	0
50 gal.	2	(Arasan) 50 percent tetramethyl thiurandisulphide	
Dichloropropane-dichloropropene		150 lbs.	0
50 gal.	0	(Dithane D-14) sodium ethylene bisdithiocarbamate	
Allyl bromide		150 lbs.	0
25 gal.	2	(Dithane Z-78) zinc ethylene bisdithiocarbamate	
		150 lbs.	0
		Zinc trichlorophenate	
		150 lbs.	0
		Ferrous sulphate	
		4,000 lbs.	0
		(Spergon) Tetrachloroparabenzoquinone	
		150 lbs.	0
		(Ferbam) ferric dimethyldithiocarbamate	
		150 lbs.	0
		DDT	
		50 lbs.	0

1/ Effectiveness on 0-4 scale: 0 = no control, 4 = excellent control.

Table 3.--Effects of ethylene dibromide on production of 1-0 seedlings, incidence of root rot, and survival in the field

Species and test	Seedbed density		Av. green weight of plantable seedling	Av. proportion of healthy + lightly affected	Field survival
	Total	Plantable			
	No. per sq. ft.		Grams	Percent	Percent
Longleaf					
Test 4.4-0; 1949					
Treated	17	13	11.4	100	96
Untreated	8	2	10.1	5	80
Test 4.4-h; 1949					
Treated	38	26	10.4	100	85
Untreated	38	20	8.7	28	79
Slash pine					
Test 4.4-h; 1948					
Treated	28	24	6.1	75	1/ 91
Untreated	28	21	6.4	20	1/ 83
Test 4.4-h; 1949					
Treated	30	22	9.8	99	83
Untreated	27	16	9.9	31	82

1/ Fair and better vigor 12 months after planting; all others four months after planting.

Table 4.--Effects of treatment and re-treatment with ethylene dibromide in an area of moderate root-rot occurrence. Data taken from 1949 pilot-plant experiment, representing four replicates per species per treatment

Treatment	Plantable		Root rot		Survival	
	Longleaf	Slash	Longleaf	Slash	Longleaf	Slash
	Number 1/		Index 2/		Percent 3/	
Not fumigated	20	16	57	57	35	85
Fumigated 1948	19	20	44	50	45	85
Fumigated 1949	26	23	1	2	76	85
Fumigated 1948 and 1949	19	21	2	1	75	85

1/ The number of plantable seedlings per square foot of nursery bed at lifting time, graded on the usual size and vigor basis.

2/ The severity of root rot on the plantable seedlings on a 0-100 scale; 0 = free from root rot and 100 = taproot entirely affected and lower part dead.

3/ Expected field survival at 12 months obtained by interpolating the root-rot index onto the survival data in table 1.

Since in two successive seasons ethylene dibromide applications to areas of known heavy infection gave higher yields of plantable seedlings which were virtually rot-free, the effectiveness of fumigation as a practical control measure seemed amply demonstrated and led to the development of the Ashe Fumigator. This is a fumigation rig that fits on a Farmall H tractor. A pump, attached to the power-takeoff of the tractor, delivers the chemical from a 50-gallon drum back of the driver's seat to a boom attached to the hydraulic lift under the tractor. Two rows of shanks, 4 and 3 per row with a lateral spacing of 10 inches, are also attached to the lift. Down the back of each shank is a metal tube with a nozzle just back of the point of the shank. The chemical is carried by individual hoses from the boom to the tube of each shank. The shanks are inserted 6 inches into the soil when the machine is operating. A small cultipacker is attached to the rear of the tractor to seal the furrows left by the shanks. The outfit can operate at approximately 4.7 miles per hour, and at this speed will treat a 6- by 415-foot nursery bed in approximately one minute.

Fall sowing.--Fall sowing has given about as striking control of root rot as has fumigation with ethylene dibromide. Unfortunately, longleaf is the only southern pine that is sown in substantial amounts in the fall.

The effectiveness of fall sowing has been observed and recorded in two compartments. In compartment 7, where infection has been heavy, only about 1/3 of untreated spring-sown longleaf was graded as either healthy or with only light infection, whereas untreated fall-sown longleaf in adjacent beds was nearly all healthy or only lightly affected (table 5).

Table 5.--Comparative data on untreated spring- and fall-sown longleaf pine at the Ashe Nursery (1946-1947)

Season of sowing	Seedbed density		Average green weight per plantable seedling	Proportion of plantable seedlings healthy or only lightly affected 1/	Survival 2/
	Total	Plantable			
	- - Number - -		Grams	Percent	Percent
Spring	7	6	15.5	35	65
Fall	37	34	10.0	98	76

1/ Affected seedlings had such slight rot that they would have passed ordinary inspection at the nursery grading table.
2/ 12 months after planting.

Sawdust.--The organic soil amendments tested in combination with mineral fertilizers included Masonite sludge, hardwood leafmold, and sawdust. Although all three organics reduced root rot, only sawdust gave evidence of fairly large benefits. The reduction in root rot was particularly noticeable in spring-sown longleaf and in loblolly pine (table 6). Three times as many spring-sown longleaf in sawdust-treated plots were healthy or only lightly affected, in contrast to seedlings from check plots; similarly, in loblolly pine, sawdust plots had five times as many healthy or only lightly infected seedlings as were found in check plots. With spring-sown longleaf, the sawdust treatments also improved field vigor slightly, but with loblolly and slash pine there was a slight reduction. The reduced survival in outplantings should not be construed as indicating that sawdust is harmful, since other tests, using a more nearly optimum combination of fertilizer and organic amendment, have shown treated seedlings to survive as well as or better than checks.

Since there is much yet to be learned about continuous application of sawdust to nursery soils and since residual effects of sawdust on incidence of disease have not been determined, it is too early to recommend its use as a major control measure. For the present, main reliance for control of root rot is appropriately placed on fumigation in spring sowings, and on fall sowing by itself.

Seedling Production and Quality

Comparison of Ashe and Stuart stock

Prior to 1942, Ashe stock had been found inferior to that from several other nurseries, including the Stuart Nursery at Pollock, Louisiana. For example, in a 1941 test when the stock was graded by identical standards and planted in intermingled rows, this inferiority was quite marked. First-year survival of Ashe longleaf was only 67 percent, in contrast to 93 percent for Stuart longleaf. It was deemed advisable to determine whether such differences still existed.

Comparisons between Ashe and Stuart stock from untreated beds were made both in the 1947 and 1948 plantings. In the 1948 test, which was the more comprehensive, Ashe longleaf samples showed almost 3 times more plantable seedlings per square foot (40 vs. 15), yet produced nearly as heavy seedlings (10.4 grams vs. 10.7 grams, green weight) and slightly better first-year survival (78 percent vs. 73 percent). For slash pine, Stuart samples showed a slightly higher bed density, but seedlings were less than half as heavy as those from the Ashe. Although survival of Stuart slash was about 9 percent higher (85 percent vs. 76 percent), first-year growth was slightly less (2 inches against 2.5 inches). Both survival and growth differences were mainly attributable to the difference in seedling size at time of planting.

Table 6.--Effect of various sawdust treatments on seedling production and incidence of root rot

Species and treatment number 1/	Seedbed density per square foot		Av. green wt. per plantable seedling	Proportion healthy and lightly affected 2/	Survival 2/
	Total	Plantable			
	- - Number - -		Grams	- - Percent - -	
Spring-sown longleaf					
1 (check)	6.3	5.6	14.4	22	62
14	8.0	7.5	18.6	63	67
15	6.3	5.8	16.8	50	65
16	5.4	5.2	19.6	76	74
Mean of treated	6.6	6.2	18.3	63	69
Slash Pine					
1 (check)	27	21	6.0	74	87
14	35	25	4.8	92	83
15	26	20	5.5	88	81
16	26	21	4.8	99	79
Mean of treated	29	22	5.0	93	81
Loblolly					
1 (check)	28	20	3.5	18	91
14	60	34	2.0	81	76
15	43	31	2.6	86	80
16	44	28	2.0	95	94
Mean of treated	49	31	2.2	87	83

1/ 1--Check; nothing added. Last pine crop in 1941. Since then cover and soiling crops plowed under each year.
14--Sawdust at 15 tons per acre plus a complete fertilizer (5-25-15) (including minor elements) at 800 lbs. per acre, and formaldehyde at the rate of $\frac{1}{2}$ fluid ounce per square foot.
15--Sawdust at 15 tons per acre plus complete fertilizer as in 14.
16--Sawdust at the rate of 30 tons per acre plus ammonium nitrate at the rate of 240 pounds NH_4NO_3 salt per acre.

2/ 12 months after planting.

Fluctuations in seedling quality occurred between years and species, but Ashe stock no longer appeared inferior. In fact, when stand density and seedling size are also taken into consideration, any basis for inferiority of either slash or longleaf stock from the Ashe disappears.

Seedbed density

A record of seedbed densities, both total and plantable, at lifting time is essential to a clear understanding and evaluation of nursery production. One of the most important factors in the cost of planting stock is the number of plantable seedlings produced per unit area. An increase of one plantable seedling per square foot in the seedbed means 32,400 additional seedlings per nursery acre--about enough trees to plant 30 acres. All major items of nursery costs remain about the same whether the plantable seedling stand is 30 per square foot (972,000 per nursery acre) or only 10 per square foot (324,000 per nursery acre).

Our knowledge of the essential qualifications of plantable seedlings is still very nebulous, as is our knowledge of the optimum densities for southern pine nursery stock. Until better information is available, the "standard" of 30 plantable seedlings per square foot may be used, but this figure is possibly high, unless total density is not more than about 35 seedlings per square foot.

Extensive sampling of seedbeds in four Ashe Nursery compartments over the past three years has revealed considerable variation in total numbers of seedlings as well as in number of plantable seedlings per square foot. In general, the highest proportion of plantable seedlings has been obtained from fall-sown longleaf, but spring-sown longleaf has yielded somewhat higher total bed densities (table 7). In number of plantable seedlings, loblolly has usually ranked a poor third. Except in loblolly pine, there has been no pronounced relationship of proportion of plantable seedlings to seedbed density in beds subjected merely to standard nursery practices.

Despite uniform treatment, the check plots from various tests in the Ashe study displayed about a hundred percent range in seedbed density, but there was no consistent trend in proportion of plantable seedlings or in seedling size for either spring or fall-sown longleaf or for slash pine. In all probability this mainly reflects the large variation in fertility levels, in tilth, erosion, drainage, and the like, within and between beds and compartments under the existing soil management practices at the Ashe, as well as differences caused by such agencies as damping-off. In this connection, allyl alcohol used at rates from 35 to 50 gallons per acre (applied at least 3 days before sowing and in water solution at the rate of one quart per square foot) gave promise of reducing stand losses due to damping-off, sand-splash, and weed competition or removal during the first few months after sowing. This material, its hazards being recognized, would deserve further trial at the Ashe or elsewhere if damping-off became troublesome or if for some reason early weed control could not be handled satisfactorily by the cheaper mineral oil sprays.

Table 7.--Number, proportion, green weight, and survival of plantable longleaf, slash, and loblolly pine seedlings from Ashe Nursery check plots, 1947-1949

Species	Seedlings per square foot			Average green weight per plantable seedling	Survival 1/
	Total	Plantable			
	Number	Number	Percent	Grams	Percent
Longleaf					
Fall-sown	37	32	86	10.6	80
Spring-sown	39	31	78	9.0	78
Slash Pine	35	25	73	6.8	82
Loblolly Pine	23	18	78	5.9	88

1/ 12 months after planting.

Seedling size

In grading stock for the various tests in this study, the rules of Region 8 (U. S. Forest Service) for minimum size, based mainly on diameter at root collar, on root length, and on height of stem (length of needles for longleaf pine), were followed except that root lengths as short as 4 inches were included in the samples. Plantable stock was not separated by grades, and seedling size was determined by weighing (to the nearest gram) bundles of 26 seedlings each, then computing average green weight per seedling.

On this basis, large variations in seedling green weight were found in different parts of the four compartments where test beds were located. The green weight of plantable fall-sown longleaf averaged about 10.6 grams per seedling against 9 grams for spring-sown longleaf; slash pine averaged about 6.8 grams, and loblolly about 5.9 grams (table 7). As might be expected, seedling weights tended to vary inversely as the seedbed density, but except for extreme densities and for loblolly pine, the trend was not pronounced.

These weights of seedlings were produced on ground that had "rested" over the war years. Despite the presumably high level of fertility resulting from the rest period, during which standard nursery fertilizing practices were applied, the average size of the seedlings appears to be small. However, lacking any record of seedling size produced in the pre-war pine crops at the Ashe, it is conjectural whether current seedling crops are heavier or lighter.

Seedling quality (or hardiness)

Quality or hardiness of seedlings from the Ashe, as from any nursery, is only partly related to size and seedbed density. Although size is very important, the fact that seedlings are large is no guarantee that they will do well when planted. Large seedlings of any given lot usually survive less well than smaller seedlings of the same lot; however, the large survivors do grow much better after they are well established.

Efforts to improve seedling quality were confined in the main to application of various mineral elements alone and in combination with organic soil amendments. Because fertility undoubtedly rose during the long rest period, it is not surprising that these soil improvement efforts over a short period of three years did not produce startling results.

Minor elements.--In two years of testing, no evidence was found that the Ashe soil was suffering from any deficiency of boron, manganese, copper, magnesium, iron, or zinc. For Mississippi soils in general, there are no reports of deficiencies of minor elements, except of boron on limed soils. The Ashe results, therefore, accord with agronomic experience and study.

Nitrogen.--In the history of nursery fertilizing programs, nitrogen has frequently been the major element used in attempts to improve seedling size and vigor. In this study, nitrogen alone rather consistently failed to boost seedling growth and usually lowered vigor of outplanted seedlings somewhat. When applied with superphosphate and potash, the mixture increased seedling size very markedly, sometimes by more than 50 percent over check seedlings. The increased size was usually associated with some reduction in bed density, particularly where nitrogen was applied before sowing. On the whole, experience with nitrogen at the Ashe showed that only in special instances, as in correcting deficiency due to a high carbon-nitrogen ratio, was it worthwhile to apply this element alone.

Phosphorus.--Current study supported the early postulations of phosphate deficiency and indicated that past phosphorus fertilizing confined to cover and green manure crops was inadequate. Phosphorus alone seldom showed much benefit, but when applied with nitrogen, or with nitrogen and potash, consistently improved seedling growth. Frequently, the combined application also improved field vigor or survival. Rates of application up to 4,000 pounds of 20 percent superphosphate per acre gave no indication that a ceiling to phosphate response had been reached. Previous applications had never exceeded 600 pounds per acre per year. This suggests that Ashe soils may have been suffering from fairly acute phosphorus deficiency for a number of years.

In most tests, superphosphate was applied broadcast before sowing and disked into the surface 6 inches of soil. This practice was regarded as desirable because it was assumed that the high phosphate-fixing capacity of Coastal Plain soils would greatly hinder the downward movement of any phosphorus applied only to the surface. Recent tests, however, have indicated marked response to side dressings containing phosphates (table 8). In southern nurseries, if post-sowing applications of fertilizers are required in areas not recently fertilized with phosphates, it is well to include superphosphate with the other mineral side dressings.

Table 8.--Improvement in vigor of spring-sown longleaf pine from post-sowing applications of nitrogen, phosphorus, and potash

Nursery bed treatment 1/	Seedlings in fair and better vigor 4 months after planting 2/
	Percent
Check	44
Nitrogen alone	44
NPK_1	53
NPK_2	69
NPK_4	63
NP	69

1/ Ammonium nitrate at 175 pounds N per acre; superphosphate at 800 pounds P_2O_5 per acre; muriate of potash at the following rates:
K_1 = 120 pounds K_2O per acre
K_2 = 240 pounds K_2O per acre
K_4 = 480 pounds K_2O per acre

2/ Based on six nursery and six field plots.

Potash.--Bits of evidence from the Ashe study, but more specifically from some other studies at the Gulfcoast Branch, indicate that some potash is required to offset possible deleterious effects of excessive nitrogen. In other words, potash is probably worth adding as insurance that seedlings will harden off adequately, since potash is assumed to play a role in drought-hardiness. The right amount of potash for best results has not yet been determined, but the data in table 8 suggest that 480 pounds K_2O per acre is too high. For a safe annual dosage, probably 120 pounds K_2O per acre (equivalent to 240 pounds 50 percent muriate of potash) may be close to the optimum for Ashe soils.

Organic amendments.--Three main types of organic amendments were tested under various conditions: hardwood leafmold, Masonite wood flour (Benaloid 1,000), and sawdust. In heavily diseased areas, all organics reduced root rot somewhat, but in other areas benefits were variable. All improved the tilth of heavy areas very materially, making lifting easier, and although no measurements were made, root development appeared to be better in plots so treated.

Hardwood leafmold was tried without any manurial additions on the assumption that it was probably pretty well balanced and possibly would introduce desirable organisms into the nursery soil.

The amount of improvement in seedbed density and seedling weight and vigor from leafmold applications was fairly consistent, although not large. Leafmold is unquestionably a safe material to use in seedbed improvement or in treatment of gall spots.

Masonite wood flour, a "waste" by-product from the Masonite process, is a brown impalpable powder, resistant to wetting and to rapid decay.

If satisfactory application methods can be developed (it is hard to handle on windy days), and the material is worked into the soil thoroughly long enough in advance of sowing to permit good wetting, it is believed that wood flour will improve soil tilth and make mineral fertilizers go further.

The beneficial effects of sawdust in reducing root rot have already been described. Other benefits are unmistakable improvement of soil tilth, seedling size, and vigor.

Bed densities in sawdust-treated plots varied from lower to higher than in check plots. No clear evidence was obtained to determine whether old sawdust (about 15 years) was better than new-fallen kerf, nor was there definite indication that hardwood sawdust was inferior to pine.

None of the sawdust tests were carried far enough to determine whether any deleterious residual effects develop or how frequently sawdust should be applied. Neither was it possible to determine whether it was better to apply sawdust directly to pine crops or to green manures. The one instance where sawdust and minerals were applied before sowing of field peas gave very promising results. The main effect of sawdust and fertilizers was to prolong the period of growth of field peas, which stayed green about a month longer than those receiving standard Ashe Nursery practice and those that received an additional light application of nitrogen. Fall and spring sowings of longleaf and spring sowings of slash pine which followed the crop of field peas grew to very creditable size without additional fertilizers.

In general, the tests showed that sawdust reduces root rot in heavily diseased areas, improves soil tilth, affords a rapid means for raising soil organic matter content, and increases seedling size and vigor if combined with proper additions of nitrogen, phosphorus, and potash. Most of these initial benefits may reasonably be expected to hold in a continuous nursery soil management program.

Time of application.--When should minerals be applied in relation to sowing of seed? This is a question of great practical significance. Obviously if minerals are to be added to soils, it is cheapest and simplest to add them dry before the beds are made up.

The Ashe study gave an opportunity to probe into this problem in several tests, although not so thoroughly as the problem warrants. Most minerals reduce bed density if applied before sowing (table 9). Lime applied before sowing caused a sizeable reduction, but when applied after sowing is certainly not harmful and may be beneficial. Like superphosphate, it can be applied dry with any suitable machinery; hence it is one of the safest materials for side dressings in acid soils where late-season damping-off may not be important.

Table 9.--Effect of pre-sowing and post-sowing applications of various minerals on final densities of seedbeds of fall-sown longleaf

Treatment	Seedlings per square foot				Av. green wt. per plantable seedling	
	Total		Plantable			
	Pre-sowing	Post-sowing	Pre-sowing	Post-sowing	Pre-sowing	Post-sowing
	- - - - - Number - - - - -				- - Grams - -	
Check	21	26	19	24	13.5	12.7
Lime 1/	12	26	12	24	24.2	14.4
Gypsum 2/	27	24	27	23	11.7	13.6
Lime + boron 3/	12	26	11	24	24.2	13.8
Florida sand special 4/	18	24	18	23	17.4	15.3
Epsom salts 5/	20	27	18	25	16.4	14.8
Mean	18	26	18	24	17.9	14.1

1/ Lime applied at the rate of 640 pounds dehydrated lime per acre.
2/ Gypsum applied at the rate of 1,400 pounds $CaSO_4 \cdot 2H_2O$ per acre.
3/ Lime + boron applied at the rate of 640 pounds lime plus 15 pounds $Na_2B_4O_7 \cdot H_2O$ per acre.
4/ Florida sand special at rate of 400 pounds 6-6-6 (+ minor elements).
5/ Epsom salts at rate of 1,400 pounds $MgSO_4 \cdot 7H_2O$ per acre.

Heavy dosages of nitrogen before sowing may also appreciably reduce bed densities. Unlike lime or superphosphate, nitrogen side dressings (and similarly potash) require care in application to prevent foliage burn. Probably the safest way is to apply them in solution and then to rinse the foliage adequately.

Pre-sowing applications frequently produced larger seedlings, but this was probably due to lower bed densities as much as to the time of application. The chief question is whether seedling quality was related to time of fertilizer application. In some tests pre-sowing applications produced seedlings of better field vigor, but the differences were not large. Seedlings side-dressed early in the season appear to be hardier than seedlings side-dressed late.

Nursery drain.--The Ashe study yielded considerable data on nursery drain in terms of green and dry weight of plant material removed. As adequate tissue analyses were not made, little can be said about the amounts of nutrients actually being removed by individual pine seedling crops. We may surmise at this stage that the amounts are quite large.

Nearly 6 tons (dry weight) of plant material are removed per acre, assuming a production of a million seedlings averaging 15 grams green weight per seedling. Naturally, these figures change as the seedling weights and bed densities change. If we assume that the average N, P, and K contents of dry seedlings are 1.2 percent, 0.2 percent, and 0.5 percent, respectively, a six-ton seedling crop removes 144 pounds nitrogen, 5 6 pounds P_2O_5, and 72 pounds K_2O per acre. Since the efficiency and recovery of the various fertilizers in pine seedling production are not known, we may only guess as to how much should be added to the soil each year for continuous crops of pine. Rates of 100 to 300 pounds N, 120 to 300 pounds K_2O, and 400 to 800 pounds P_2O_5 were used at the Ashe, and may represent desirable working ranges fairly closely, depending on condition of soil, degree of erosion, and similar factors.

Erosion is one of the most important agencies altering the quality of seedbeds in any nursery located, like the Ashe, on rolling land; the soil management program must be geared first to deal effectively with this problem before improvement in other aspects of soil management can be fully achieved.

Recommendations

Following are, in brief, the recommendations made to the Ashe Nursery as a result of this study. The problem at the Ashe is perhaps not unique; the remedial measures outlined here may possibly find wider application, particularly in other southern nurseries.

Recommended procedure for control of root rot

1. Fall-sown longleaf.--Where longleaf is fall-sown, no further precaution against root rot is deemed necessary.

2. All spring-sown species.--Areas with previous root-rot history and other areas initially used for spring-sown species should be fumigated with ethylene dibromide. When the severity of disease occurrence is not known, it is suggested that a few scattered beds be left untreated for the initial crop. If the disease does not appear or is only light in the untreated beds of an area, it is suggested that such an area be left untreated for the next pine crop and for subsequent pine crops until the severity of root rot warrants the control

treatment. Fumigation of the initial pine crop, and as warranted for subsequent crops, should be carried out as follows:

Material: Ethylene dibromide. Dowfume W-40 was the form used in all experimental trials. A more concentrated form of the chemical, Dowfume W-85, is now available and it is suggested that this form be used because of the savings in cost, freight, and storage space.

Cost of material in 1949: Dowfume W-40, $1.92 per gallon; Dowfume W-85, $4.45 per gallon. The latter is approximately the equivalent of paying $1.40 per gallon for W-40.

Rate of application: 30 gallons per acre of W-40 or 9 gallons per acre of W-85. The latter may be diluted with mineral spirits, 3 parts to 7 parts respectively, to give a concentration equal to the W-40 if application of the larger quantity (30 gallons per acre) should prove more feasible.

Time of application: October or later, allowing at least a 3-week waiting period between fumigating and sowing pine.

Method of application: By use of the Ashe Fumigator. This machine delivers the fumigant in a continuous flow, at a depth of 6 inches, with 10-inch spacing between rows, and treats a strip 6 feet wide. Thus, one trip with the machine treats one bed width from center of alley.

Condition of soil at time of treatment: The soil should be tilled as for planting but the beds should not be thrown up; soil should be moist but workable; the soil temperature should be between 50° F. and 75° F.

Working soil after treatment: Immediately prior to sowing, the soil may be worked to a depth not to exceed that at which the fumigant was injected. Working the soil, such as is done in throwing up the seedbeds, probably allows the dissipation of any remaining fumigant and thus forestalls possible chemical damage to the pine seedlings.

Recommended procedures for improvement of soil fertility

Several conditions or situations exist or may develop at the Ashe Nursery, each requiring somewhat different soil-management practices.

On much of the still-arable portion of the nursery, no pine or other crops have been removed for several years. These areas may need only addition of minerals before sowing the first new pine crop following the rest period.

On areas where a pine crop has been harvested from rested land, it is recommended that after the pine crop sawdust and minerals be applied, followed by soiling crops for one season. This treatment would precede a 2:1 rotation of pine and green manure cover crops.

Occasionally it may be necessary to sow consecutive crops of pine on areas which have not been amended with sawdust. Such areas can be treated to advantage with sawdust and minerals before sowing the second pine crop.

When seedlings get off to a slow start or fail to maintain thrifty growth, suitable side dressings should be applied.

Finally, where gall spots have formed, heavy applications of sawdust or leafmold with appropriate mineral additions may restore seedling production to a satisfactory level.

The recommended procedures for each of the situations or conditions described in the foregoing paragraphs are specified below:

1. Where minerals are applied to rested areas before sowing pine (applies to most of the Ashe Nursery not in seedbeds during 1950).

(a) Add 3,000 pounds 20 percent superphosphate (600 pounds P_2O_5) and 240 pounds 50 percent muriate of potash (120 pounds K_2O) per acre broadcast before disking, then disk into surface 6 inches of soil. In fertile areas, the dosages may be reduced to 2,000 pounds superphosphate (400 pounds P_2O_5) and 200 pounds KCl (100 pounds K_2O) per acre.

(b) About 15 days after germination (burlap removal), add 100 pounds ammonium nitrate (approximately 35 pounds N) per acre in liquid form, rinsing foliage immediately after application. Repeat this process 2 more times at 15-day intervals.

2. Where sawdust and minerals are added before sowing area to field peas or other green manure crop. (This treatment applies to areas in seedbeds during 1950, and to most of the Ashe after the first "post-rest" pine crop has been harvested. In general, it is the most attractive treatment because it should require no side dressing, and at least in the better compartments can be used on a 2:1 rotation of pine versus soiling crops.)

(a) Broadcast sawdust at the rate of 20 tons (equivalent to a 1-inch layer or 135 cubic yards) per acre.

(b) Broadcast 600 pounds ammonium nitrate per acre and 300 pounds 4-8-8 commercial mix.

(c) Disk sawdust and minerals into surface six inches of soil at least two weeks before sowing field peas.

(d) Sow field peas on regular schedule. If two pea crops are sown in the same season, add 300 pounds 4-8-8 commercial mix with second sowing of peas.

(e) When peas are ready to plow under for fall sowing of pine, broadcast 3,000 pounds 20 percent superphosphate and 240 pounds 50 percent muriate of potash per acre, then plow or disk field peas and fertilizers into surface six inches of soil; follow by sowing to pine.

If area is to be sown to pine in the spring, plow field peas under in the fall in usual manner, adding only the regular 300 pounds 4-8-8 commercial mix for the winter cover crop. Before cover crop is plowed under the following spring, broadcast the 3,000 pounds 20 percent superphosphate and the 240 pounds 50 percent muriate of potash, then work both cover crop and minerals into soil in preparation for spring sowing of pine.

(f) No side dressing should be necessary for the first pine crop following the above treatment. However, if during the growing season areas show up where seedlings look pale and unthrifty, add nitrogen at rates and intervals as listed under 1-b.

(g) After the first pine crop is harvested, the same area may be used for spring sowing of a second consecutive pine crop. Before sowing pine, broadcast 3,000 pounds 20 percent superphosphate and 240 pounds muriate of potash per acre as under 1-a, disking same into surface six inches of soil. Side dress in the second growing season as under 1-b only if the seedlings fail to develop in a reasonably thrifty manner.

(h) After the second pine crop is harvested, start sawdust and mineral treatment all over again as in 2-a through 2-c; then sow field peas, and follow through as in 2-d to 2-g, inclusive.

(Note: If compartments have been badly depleted by erosion it is recommended to skip the second consecutive pine crop, and follow a 1:1 rotation a second round before shifting to a 2:1 rotation of pine and green manure.)

3. Where minerals are applied with sawdust before sowing pine (this applies to areas needed for pine production before there is an opportunity to go through the sawdust-mineral-green manure programs):

(a) Apply sawdust at the same rate as under 2-a, and superphosphate and muriate of potash as under 1-a. Disk all three materials into surface soil.

(b) Begin adding nitrogen 15 days after burlap removal and continue as under 1-b. If yellowing shows up after July, make additional applications of nitrogen until greenness is restored.

4. Where all minerals are added in post-sowing application (this treatment is recommended for individual beds where seedlings are small and lack good color):

Apply 20 percent superphosphate in dry form at the rate of 1,600 pounds per acre (320 pounds P_2O_5). Follow up P_2O_5 application with muriate of potash at the rate of 120 pounds per acre (60 pounds K_2O), and ammonium nitrate at the rate of 100 pounds per acre (35 pounds N), with both KCl and NH_4NO_3 mixed in the same water solution and applied by gravity feed from a tank on a tractor-drawn dolly. Rinse foliage

immediately after application. Repeat above dosages two or three times at 15-day intervals until seedling thrift appears satisfactory.

5. Where subsoil is exposed by erosion, or where areas of heavy soils or excessive crusting occur because of erosion or other reasons:

(a) If leaf mold is available, apply locally in 2-inch layer (about 270 cubic yards per acre); broadcast 20 percent superphosphate at the rate of 4,000 pounds per acre (800 pounds P_2O_5) and 50 percent muriate of potash at the rate of 400 pounds per acre (200 pounds K_2O). Disk leafmold and minerals thoroughly into surface six inches of soil, then sow to pine if needed, otherwise to green manure or cover crop in the regular manner.

(b) If sawdust is used, apply at the same rate as leafmold above; add superphosphate and muriate of potash also as in 5-a above, plus ammonium nitrate at the rate of 600 pounds (200 pounds N) per acre. Work sawdust and all minerals thoroughly into surface six inches of soil. If area is needed for pine, wait at least 3 weeks before sowing. (It is preferable to follow treatment with green manure or cover crop sown in the usual manner before using area for pine seedlings.)

(c) Repeat treatment 5-a or 5-b in successive years until mellowness and good tilth of gall spot are restored.

N.B.: In all instances, if the analyses of the fertilizers obtainable at any given time differ from those prescribed, appropriate adjustments in dosages should be made and reaction of the soil tested. For example, neither ammonium sulphate nor nitrate of soda is equivalent to NH_4NO_3 in elemental nitrogen content or in reaction (pH). Exclusive and repeated use of the former will acidify the soil; similarly, the latter will tend to neutralize the soil or bring about an alkaline reaction.

6. The general problem of erosion: Since the Ashe Nursery is on sloping land, it will always have to wage an unceasing battle against soil erosion. None of the recommendations listed above are specifically designed to reduce erosion, though most of them will help restore productivity to areas depleted by soil loss; all of them will be less effective to the degree that accelerated erosion continues to gnaw away valuable topsoil.

Badly eroded areas, as well as areas of high erosion potential, might well be taken out of use, concentrating seedling production on the better portions. Under intensified practices, it should be possible to step up seedling production by adopting at least a 2:1 rotation, thus compensating for the reduction in acreage.

Costs

Cost of fumigation with Dowfume W-40 has been about $60 per acre. With the concentrated Dowfume W-85, this could be reduced to $50 per acre or less. On a crop of a million seedlings per acre, this

amounts to 5 to 6 cents per thousand, a very nominal cost. Since fumigation is necessary only in spring-sown areas harboring serious infection, this item is insignificant in relation to the benefits.

Cost of fertilizers and soil amendments is somewhat greater but still well within practical limits of operation. Maximum costs of minerals applied per acre are approximately as follows:

600 pounds 32.5 percent ammonium nitrate	$18.00
3,000 pounds 20 percent superphosphate	50.00
300 pounds 50 percent muriate of potash	12.00
600 pounds 4-8-8 commercial mix	15.00
Total minerals	$95.00
One-half the cost of spreading, hauling, and mixing 135 cubic yards of sawdust (since sawdust will suffice for 2 pine crops)	$85.00
Total sawdust and minerals per acre	$180.00

The sawdust costs are liberal because they are based on a relatively inefficient hand-loading operation, using trucks that averaged only 3½ yards per load. But even on this basis, and assuming a crop of a million seedlings per acre, the cost of minerals and sawdust amounts only to 18 cents per thousand. Thus, the total program for both fumigation and soil improvement costs not more than 25 cents per thousand; or less than 10 percent of the legendary production figure of $3 per thousand!

Summary

1. The Ashe Nursery study, begun in November 1946, was aimed at controlling root rot and improving soil fertility and seedling size and quality at the Ashe Forest Nursery near Brooklyn, Mississippi.

2. During the 3-year study, approximately 110 standard nursery beds were sown to longleaf, slash, and loblolly pine in various tests on root rot and soil management. Over 200,000 seedlings were individually examined and handled in the laboratory and field, of which over 100,000 were planted in experimental plots. More than 3 million surplus seedlings were supplied for regular planting.

3. Ethylene dibromide ($BrCH_2 \cdot CH_2Br$) in a 20 percent (by volume) solution at the rate of 30 to 32 gallons per acre gave excellent control of root rot. Fall sowing of longleaf pine also controlled root rot adequately, and sawdust at the rate of 135 cubic yards per acre (1-inch deep layer) also reduced incidence of disease very materially.

4. Soil fertility investigations indicated that the Ashe soils were deficient particularly in organic matter and phosphorus.

5. Addition of sawdust, ammonium nitrate at the rates of 300 to 600 pounds, 20 percent superphosphate at the rate of 3,000 pounds, and 50 percent muriate of potash at the rate of 240 pounds per acre are deemed a necessary treatment to sustain production of seedlings of satisfactory size and vigor (the minerals to be applied annually, the sawdust triennially).

6. Cost of fumigation with ethylene dibromide amounts to about 5 or 6 cents per thousand, and cost of an adequate mineral and sawdust program about 18 cents per thousand; these costs are based on an estimated production of a million plantable seedlings per nursery acre.

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